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NATIONAL COMMITTEE ON SCIENCE & TECHNOLOGY

F.C

DRAFT SCIENCE AND TECHNOLOGY PLAN
(1974 - 79)

VOLUME II—SECTOR-WISE

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PREFACE

For the first time in the country an overall Science and Technology Plan has been prepared by the National Committee on Science and Technology, as an integral part of the socio-economic Fifth Five-Year Plan. In the first volume, a companion volume to the present one, the implications of the guiding philosophy underlying the S & T Plan have been spelt out in terms of the required institutional and implementation framework, the areas where technological effort needs to be directed or structured, and some areas of highlight that have emanated from the exercise in S & T planning.

The present volume indicates the specific areas and programmes that enter within the compass of the S & T Plan. To arrive at the plan the techno-economic system was viewed in terms of twentyfour sectors. Each sector was further subdivided into appropriate sub-sectors, and for each sub-sector a group was formed to assess the technological capabilities developed so far, and areas where there was need to develop the required skills and organisations. The further development of technological skills to be undertaken was cast, as far as possible, in terms of specific projects. The detailed reports prepared by the various groups, on the basis of which the S & T Plan has been formulated are being published separately.

The sectoral approach has proved to be a convenient tool for planning, for defining the various activities comprising the technological system at its interface with the socio-economic one. It has helped in emphasising the intra-sectoral and inter-sectoral relations between the variety of technological activities, relationships which in some cases already exist, and in others where they need to be arrived at amongst existing organisations, or through the creation of organised activity relating to, say, engineering design in the area of industrial technology. It would then be observed that in the S & T Plan there are to be found programmes in different sectors which are connected; the programmes relating to the fertiliser industry is one such example. One may also find outlays shown against activities where meagre attention had been paid in the past.

A self-reliant social-economic-technological system, in order to be achieved, demands the creation of a network of relations and activity. It demands not only the attention of the government but a keen user-interest on the part of the entrepreneurs, be they in the public or the private sector of our economy. By its inherent nature—the minutiae requiring a detailed specialist knowledge, skills and experience-technological activity cannot be carried out in a soley centralised fashion. Nor can it be carried out in the form of a *laissez-faire* decentralised fashion if one is to avert an avoidable multiplicity of resource commitment, and if one desires to shorten the time-spans of development. For the country's fuller technological development what one has to aim at is a harmonious mix of government and private investments. Conscious of the fact that self-reliance in terms of technological skills forms the bed-rock of a self-reliant economy capable of endogenic economic growth and development, the S & T Plan calls for a truly national commitment of talents and resources available within our country. Thus, despite the fact that organisations capable of implementing the S & T Plan were located, or projected, it is with the intent of drawing on the full panoply of our national resources and organisations that the draft S & T Plan contained in the present volume is being presented to the public. It is also being presented under the anticipation that other programmes which have escaped the attention of the planners may also ultimately find a place in the S & T component of the Fifth Five-Year Plan.

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SECTOR—NATURAL RESOURCES

NATURAL RESOURCES

A. *Introduction*

The Natural Resources of a country constitute the bed-rock of its economy, and per-capita consumption of natural resources is a vital index of a country's economic development. The per-capita consumption of energy, minerals and other natural resources in India is miserably low as compared to that in advanced countries. With more than 15 per cent of the world's population, India accounts for only 1.5 per cent of the world's energy consumption. Even the mode of production of energy in the country is predominantly through living (e.g., human and animal labour) and non-commercial (e.g., wood, vegetable-waste and dung cakes, etc.) sources. Only about one third of energy is obtained through commercial sources like coal, hydro-power and petroleum.

Most of the advanced countries have given the highest priority to the development of natural resources, as a vanguard to accelerated programmes of industrialisation. In contrast, our total efforts for exploration, development and conservation of natural resources have been extremely meagre. Integrated approach to resource development has been practically absent. The policies and planning in the natural resources sector have been practically absent; short-term plans have been subservient to expediency.

Exploration, exploitation and conservation of natural resources, meteorology and the environment in which we live are interwoven and inter-dependent. Forestry practices directly affect water supplies, fish and wild-life. Flood control or water projects likewise have impact on other resource values. Mineral development and utilisation can, if carelessly done, destroy other resource values and result in serious water and air pollution.

Apart from environmental pollution relating to water and air, there are environmental disasters like cyclones, floods, etc. which are intimately connected with weather forecasting. Weather prediction plays a very important role in agriculture and considering the fact that 46% of our GNP comes from the agricultural sector, we have to give due importance to meteorology as it relates closely with water resource development, agriculture, irrigation and power.

It is generally accepted that in a developing country the resource consumption increases at a rate much faster than population growth and if the present trends continue, India's demand for minerals, and energy requirements could increase by more than 200 per cent by the year 2000.

B. *Present Status*

Minerals.—Of the 3.28 million sq. km. of the country, 1.03 sq. km. are sedimentary areas favourable for petroleum, natural gas and ground water resources; 0.52 sq. km. are covered with the Deccan lava flows, and the remaining 1.73 sq. km. need to be explored for minerals. Nearly 56% of the country's land surface has not been mapped geologically on 1 : 1 mile scale. A total of only 500 odd geophysical investigations have been carried out by the Geological Survey of India for minerals, and engineering problems since 1956. So far only 20% of land surface has been surveyed by reconnaissance geology and hardly 100 geophysical studies have been made by the Geological Survey of India for ground-water since Independence. Our success ratio for explorating groundwater tube-wells was at a low figure of about 35% whereas in countries like Israel it is between 82% to 85%.

Fuels.—Adequate energy resources and their utilization form the very basis of any industrial economy. In India, 1965-66 figures available indicate energy produced through commercial sources, i.e., coal, hydropower and petroleum provide only 29.5% of the total energy needs, the non-commercial sources such as wood, vegetable waste and dung cakes providing 31.4% and the remaining 39.1% coming from living resources which include human efforts, animal efforts and bullock carts.

The current annual production of oil by ONGC is over 4 million tonnes. Oil India Ltd., and Assam Oil Company together produce about 3 million tonnes, thus bringing the total indigenous production to about 7 million tonnes whereas the actual requirement is of the order of 20 million tonnes. The future projected requirements for 1975 and 1980 are 30—35 million tonnes and 40—45 million tonnes respectively.

Water.—In 1951, the total area under irrigation from all sources was 56 million acres India's surface water resources can irrigate nearly 203 million acres out of a total cultivable area of 447 million acres. By 1969, about 93 million acres were brought under irrigation out of 387 million acres of area that was under cultivation by 1966-67. The total surface water resources of the country have been estimated to be 1356 million acre ft. out of which utilizable quantity would be of the order of 450 million acre ft. By 1951, only 17 per cent of this potential was utilized and by 1959, this percentage was improved to 37, still leaving a substantial quantum of water to be fruitfully utilized. As regards groundwater, the estimated utilization with respect to irrigation, industrial use, domestic and live-stock in 1971-72 is of the order of 10.00, 0.10, 0.37 million hectare metres respectively, and the projected demand for 1978-79 is 14.35, 0.19 and 0.46 million hectare metres respectively. Only about 37% of surface water is being utilised at present and much less of the groundwater potential.

Forests, Land and Soil.—Of the total land available, about 45% is under cultivation, 22% under forests and the remaining 33% consists of areas not available for cultivation due to various reasons including ravines, saline, arid and fallow lands. Reclamation of large parts is possible through better drainage, soil conservation, chemical and biological quality control of soils. Experts have realised this but field level efforts have remained lacking. Forests cover only 22% of the land areas whereas according to the national forest policy it should be around 33%. Despite all plans for afforestation, a steady destruction of forests seems to be continuing unchecked. The free nibbling of grass by cattle is one of the most important causes of soil erosion. About 150 million hectares out of 300 million hectares are estimated to require soil conservation measures. Costly reservoirs constructed under River Valley Projects are being silted due to denudation and over-grazing.

Wild life.—The rich variety of wild life in India is surpassed only by a few countries in the world and it is sad that many species such as tiger, wolf, rhinoceros, musk-dear, white crane, peacock, pheasant, crocodile, etc. are being driven to the verge of extinction.

Geodetic and Topographic Surveys.—Maps are the basic pre-requisite for all economic and industrial developmental projects and natural resource surveys. The Survey of India which is more than two centuries old, lags behind considerably in the fulfilment of national needs. Delay in production of maps affects timely execution of natural resources developmental programs. The time-lag in production of maps and survey is about 5 to 7 years now. Many areas are either not mapped or their existing maps not revised even though a recycled period of 25 years was accepted as far back as 1905.

Dependence on Imports.—So far, the country has been heavily dependent upon the import of metals, minerals, petroleum, etc. to meet its demand. The annual import like iron, metalliferrous ores, metals, minerals, crude oil and petroleum products and raw materials for lizers account for an annual import bill of over Rs. 800 crores. This figure is likely to to over Rs. 1200 crores annually by the year 1980-81.

NCST Approach to R&D Planning in Natural Resources Sector

Recognising the role of R&D exploration and exploitation of natural resources and impact on economic and social development, the NCST constituted a panel to go into the sent status and to identify gaps in R&D and in institutional framework with a view to ure a more effective exploration, exploitation, utilization and management of these resources. r purposes of broad categorisation, the NCST panel has sub-divided the natural resources tor into the following six sub-sectors.

1. Forestry, Land, Soil and Wild Life.
2. Oil and Natural Gas.
3. Geodetic and Topographic Surveys.
4. Mineral Resources.
5. Water Resources.
6. Environmental Sciences.

A total number of 65 sub-committees have been constituted in these different sub- ctors involving directly about 315 scientists and technologists in the formulation of the R&D an. In addition, the views of a large number of university professors, industrialists, scientists d Technologists have been elicited and have been considered by the respective sub-committees.

The reports of the subsectors have been discussed in the respective planning groups. he summary of the reports is as follows:—

Io.	Sub-sector	No. of Sub-Committees	Financial outlay (Rs. in crores)
	2	3	4
1.	Forestry, Land, Soil & Wild Life	12	22.71
2.	Oil & Natural Gas	7	16.96
3.	Geodetic & Topographic Surveys	7	14.37
4.	Mineral Resources	13	26.65
5	Water Resources	20	93.26
6.	Earth Sciences	6	10.08
	Total :	65	184.03

The NCST Planning Group on 'Earth Sciences' has identified "Astronomy and Astro- hysics" as an important area not dealt by any of the other panels of NCST and therefore sub-committee has been constituted to identify gaps in R&D efforts and to propose concrete rojects. Since this discipline almost falls under the purview of the panel on "Education and cientific research", the projects amounting to Rs. 450 lakhs has been passed on to that panel r inclusion in their proposals. Similarly some projects from the Mineral Resources sector nd Forestry, Land, Soil and Wild Life sector have been removed by the NCST to avoid duplication with those from other Panels. The summary of the outlays Ministry-wise is given below :—

Outlays proposed (including State Governments)

(Rs. crores)

Agency Ministry	Geodetic & Topographic Surveys	Forestry, Land Soil and Wild Life	Oil & Natural Gas	Minerals	WATER		Earth Sciences	Total
					Surface	Ground		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. CSIR	..	1.56	..	2.59	..	.97	1.98	7.10
2. ICAR	..	7.00	..	..	..	..	..	7.00
3. Deptt. of Atomic Energy.	..	..	..	2.87	..	..	0.26	3.13
4. Deptt. of Space	1.00	..	..	.75	..	..	0.49	2.24
5. UGC (Universities)	.10	.33	..	.76	.50	1.33	0.91	3.93
6. Ministry of Education (including IITs/IISc.).	.05	..	..	.85	..	.44	0.06	1.40
7. D.S.T.	13.22	..	..	.07	.50	..	0.10	13.89
8. Ministry of Petroleum & Chemicals.	..	..	16.96	..	..	..	0.97	17.93
9. Ministry of Industrial Development	..	..	..	..	..	..	0.46	0.46
10. Min. of Steel & Mines (Deptt. of Mines).	..	..	..	18.58	.25	..	0.80	19.63
11. Ministry of Agriculture.	..	13.76	..	..	3.28	5.95	..	22.99
12. Min. of Irrigation & Power	..	..	..	.07	79.62	..	0.20	79.89
13. Min. of Tourism & Civil Aviation.	..	..	..	.04	.07	..	3.85	3.96
14. Min. of Planning	..	..	..	.04	..	..	..	0.04
15. Min. of Works & Housing.	..	..	..	..	.03	..	..	0.03
16. State Governments	..	.06	..	.03	.02	.30	..	0.41
TOTAL :	14.37	22.71	16.96	26.65	84.27	8.99	10.08	184.03

D. *Integrated approach to Natural Resources Management*

Effective action is necessary to quickly meet the immediate needs with respect to minerals, water, oil, and other natural resources which are very basic for survival of man and to sustain our industry, agriculture and the economy in general. At the same time, in problems relating to Natural Resources it is necessary to have long term planning, each short term action fitting into long term objectives. Systems approach should be adopted for management of Natural Resources where all aspects leading to exploration, exploitation, conservation, environmental control, pollution and ecological balance, R&D and management should be components of a single system—the basic step towards such integrated systems approach will be to establish a Data Bank and prepare an inventory of Natural Resources. R&D will be but one component of this system.

Presently, work relating to Natural Resources is scattered over several central ministries and numerous state departments and other agencies. The problem of shortages in India with respect to food and water is not due to lack of resources but due to our inability to look for ahead and take timely decisions. It is no longer resources that limit decisions but decisions that make resources. To achieve the desired integrated approach to management of natural sources, it is necessary to constitute a Natural Resources Commission to evolve long-term integrated natural resources plan and coordination over verse sectors.

The need to look ahead is imperative and we must turn from management by reaction to management by anticipation of problems, in planning for long-term strategies for development and utilisation of Natural Resources.

Subsector : FORESTRY, LAND, SOIL AND WILD LIFE

The forests are our greatest renewable natural resources. Unlike oil and minerals, our forests, if properly managed, are self-perpetuating. In addition to their importance as a source of raw material, forests also provide far reaching benefits. Over a vast portion of our land surface, forests conserve irrigation, water, protect the soil, regulate stream flow, provide places of public recreation and afford a suitable environment for wild life.

With the rising population and the demand for a higher standard of living, a comprehensive program to disseminate technical information should be chalked out for the management and productivity of the forests and their impact on the environment. The percentage of area under forests for our country is only about 22 as compared to 40.6 of USSR, 44.5 of Canada, 31.6 of USA and 69.1 of Japan.

Though the total area under forests is of the order of 72 million hectares, it is often neglected and hence the contribution to the gross national product from the forestry sector is only 1.6% compared to the contribution of 46% from the agricultural sector (during 1969-70). The National Commission on Agriculture had rightly recommended a changeover from the conservation oriented forestry to a more dynamic programme of production forestry to meet the requirements of wood and wood based industries. This will generate employment opportunities in the rural areas and backward regions of the country.

The consumption of paper is regarded as a good index of development of a country. In India, per capita consumption of paper is only 1.4 kg. as compared to 7 kg. in the UAR, 16 kg. in the USSR, 57 kg. in Japan, 106 kg. in UK and 285 kg. in USA. With the economic development of our country, demand for wood and wood products continues to rise. This cannot be attained unless a comprehensive programme for stepping up the production is taken up. The present consumption and estimated future requirements for industrial wood are 8.92 million m^3 in 1970, 25.55 million m^3 in 1908 and 41 million m^3 in 1990.

The production has to be stepped up by man-made forests which involves introduction of exotics. Yet another way to bridge the gap between the demand and short supply is to tap the substantial resources of silver fir and spruce. Extensive areas of forest which have been reduced to poor quality due to ill treatment also holds potentiality if new silvicultural techniques could be introduced. Enhancing availability of raw material needs production of pedigreed seeds for commercial planting to ensure faster rate of growth, better wood properties and resistance to diseases and pests. All these need integrated research in tree breeding, physiology and ecology.

The prevalent methods of logging being primitive, an effective way of meeting the demand is to resort to improved logging techniques. To make the fullest use of our natural timber resources and for bridging the gap between supply and demand of wood, it is necessary to carry out intensive research in the field of well logging and develop tools and machines indigenously and make them available to users at reasonable prices.

Proper research, to control the pests, diseases and damage and to maintain the health of forests is necessary. Creation of wood-lots, growing of fodder trees all around cultivated areas, providing wind breaks and shelter belts and grazing for the cattle constitute essential factors of the village economy.

In spite of some advances made in the various fields of wood science during the last 50 years, there are still some gaps in our understanding and knowledge of certain fundamental aspects of the nature and behaviour of wood. Moreover, reliable basic data is not available and basic information on the existing state of different wood based industries are also lacking which are both essential for a more efficient utilization of timber wealth and also for proper research endeavour for the country's urgent needs like housing and also to meet the increasing demand of wood industries.

Intensive research has to be done for the increased production of fibrous raw materials for the development of technology of processing non-conventional raw materials and development of packaging and coated paper and cellulosic derivatives which are essential for the high demand of paper and newsprint. In addition to its important role in rural and industrial economy, the minor forests also produce plants of medicinal and aromatic value.

There is hardly any area in the country free from hazards of soil erosion, sedimentation and deterioration of land and frequent droughts and floods. 145 m. ha. out of 305 m. ha. are estimated to be in need of conservative measures. The damage on account of floods in of the order of Rs. 100 crores every year. Costly reservoirs constructed under river valley projects are being silted due to denudation. To meet the situation, reorganisation of the existing Soil Conservation Research and Training centres, where various problems of land-use can be studied, is necessary. Development of hydrologic instruments are urgently required to be taken up for watershed investigations.

Land resources are the most important natural wealth of our country and out of the total geographical area of 327.6 million hectares, the total cultivable area presently available is about 194 million hectares. Land is put to use for production of food, fodder etc. in addition to its various uses in forestry and related requirements which have immense value to Indian agricultural economy. The quality of soil, its fertility level, productive capacity, situation, topography and slope of the terrain are all various factors which govern land resources utilisation. Problems of land usage under various conditions whether they are rain-fed or irrigation-fed have to be studied from various angles, including conservation measures and a continuous study of productivity. Good land usage ensures continued fertility and benefit to the national economy, while poor usage of land depletes fertility. There is urgent need for a comprehensive land productivity survey as well as study of the different usages, land is currently put to. Efficient utilisation of all resources in relation to land requires adaptation of improved technology in agriculture and various other considerations.

The rich variety of wild life in India is surpassed by no other country in the world. The conservation of wild life means the wise use and management of non-domesticated animals for the benefit of the community. Wild life provides the best and the most thrilling recreational resources in the country. Unfortunately, in India many species like tiger, wolf, musk-deer, wild crane, peacock, pheasant and rhinoceros are being driven to extinction. There is a great need to undertake an inventory of wild life resources of our country. It has now been realised that wild life is renewable resource and can be profitably cropped to the mutual advantage of both man and wild life. An effectively organised and adequately equipped research base for wild life should include censusing, study of ecology, inter-relationship between domestic and wild life, establishment of breed-pens, game farms, natural parks, etc.

The NCST has taken the initiative to stimulate R&D activities in the above important areas and with the active assistance of Forest Research Institute (FRI), Dehra Dun, and other organisations. Twelve sub-committees have been formed to identify gaps in R&D and to suggest concrete projects so that forest productivity could be enhanced, and suitable timely steps are taken towards problems dealing with wild life preservation, soil conservation and land utilisation. The outlay, with the sub-committees are indicated below :—

(Rs. in lakhs)

S. No.	Sub-Committee	Financial outlay (included in the plan)
1	2	3
1.	Plant introduction, silviculture and management	310.10
2.	Plant breeding, physiology and ecology	157.90
3.	Protection from pests and diseases	101.10
4.	Farm forestry and range management	200.00
5.	Wood sciences (1)	276.10(1)
6.	Pulp and paper products (2)	509.00
7.	Minor Forest Produce	172.30
8	Harvesting and extraction	50.30
9.	Wild life and environmental conservation	135.50
10.	Land use	300.00
11.	Watershed management and flood control	400.00
12.	Soil and soil/plant relationship	167.50
	TOTAL	2270.80

(1) An outlay of Rs. 156.40 lakhs which has to be provided by the private sector has not been included.

(2) The amount of Rs. 509.00 lakhs have been suggested under the Hindustan Paper Corporation and have not been included in the total.

All these R&D programmes are designed towards afforestation programs of the States and n improving forest productivity which in turn improves the rural economy of the country as whole, apart from generating employment potential in villages. The FRI and its regional entres will be responsible for coordination of most of these projects, but in actual working, the tate Forestry Departments and Agricultural Universities will be involved.

The Projects identified by the Sub-Committees are given in the following pages :—

Project with Financial outlays

Project Index No.	Title of the Project	Financial Outlay (Rs. lakhs)
1	2	3
	A_1: Plant Introduction Silviculture & Management	
$S_2G_1A_1P_1$	Studies on introduction of important exotic tree species including seed procurement	53.4
2.*	Establishment of a data processing centre at F.R.I.	25.0
3.*	Studies on rehabilitation of degraded forests	8.5
4.*	Expansion of seed testing laboratory, FRI, Dehra Dun and establishment of seed testing laboratories at Kanpur, Jabalpur, Coimbatore and Gauhati.	29.4
5.*	Studies in production economics of plantation crops and natural forests	21.5
6.*	Fire and Fire protection research	20.0
7.*	Creation of a forestry documentation centre	10.0
8.*	Studies to develop technology of regeneration of spruce and fir.	21.0
9.*	Forest floras project	12.5
10.*	Revision of 'Indian trees'	3.0
11.*	Thinning and spacement research in economically important tree species	32.0
12.*	Research on afforestation of special sites	20.2
13.	Investigation on the efficiency of statistical sampling methods with a view to evolve suitable sampling techniques in forestry surveys.	5.0
14	Research on demand and market studies of wood raw materials	14.0
15.	Investigation in Natural and artificial regeneration of evergreen forests	15.0
16.	Photo-interpretation cell in F.R.I., Dehra Dun	12.3
17.	Weed control in forestry	7.3
	TOTAL A_1	310.1
	A_2: Plant Breeding, Physiology and Ecology	
$S_2G_1A_2P_1$	All-India-centre-*cum*-states coordinated project for the genetic improvement of forest tree species.	80.0
2.*	Forest productivity	6.0
3.*	Genetic improvement of promising exotic conifers and some selected native pines	4.0
4.*	Breeding disease resistant forest trees in eucalyptus spp. and santalum album	5.0
5.*	Studies on photocontrol of growth and dormancy in some important forest trees	3.0
6.*	Studies on dormancy in trees	4.0
7.*	Environmental conservation	7.0

1	2	3
8.*	Dynamic change in the microclimate as correlated with forestry practices such as : (a) Seeding felling in sal, (b) Thinnings in sal (separate for each thinning grade), (c) Shrub cuttings in teak forest, (d) bamboo cutting in teak forest, (e) various canopy manipulation in evergreen forest (including tunnel plantings).	10.0
9.*	Setting up of a radio-isotope laboratory for tree physiology studies	6.0
10.*	Studies on induced polyploidy and mutegenesis in some hardwood tree species . .	2.1
11.	Studies on the genetic basis of wavy grain in red sanders (Pterocarpus santalinus l.f.) and methods to increase the frequency of trees with wavy grain.	1.3
12.	Physiological and biochemical studies on regeneration in forest tree species . . .	6.0
13.	Physiological and biochemical studies on growth and development of some forest tree species.	6.0
14.	Ecological studies in Indian forests	4.0
15.	Selection of high-resin-yielders of chir pine (pinus roxburghii) and hybridization to evolve new strains.	2.5
16.	Organisation of a National Institute of forest genetics and tree improvement . .	5.0
17.	Studies on the effect of fertilizer application on growth and development in Pinus patula and Eucalyptus tereticornis.	4.0
18.	Studies on the physiology of oleore-sin formation in pines	2.0
	TOTAL A_2	157.9

A_3 : Protection from Pests & Diseases

1	2	3
$S_1G_1A_3P_1$*	Survey of insect pests and diseases and their control	48.0
2.*	Studies on Sandal spike diseases and its control	11.0
3.*	Establishment of post-entry quarantine and phytosanitary unit at F.R.I., Dehra Dun .	13.2
4.*	Biological control of noxious weeds	8.5
5.	Strengthening of the marine organism scheme centre at Madras	6.9
6.	Behaviour physiology and host relationships of forest insects with reference to teak defoliators in relation to their establishment and management.	3.5
7.	Autocidal-cum-biological control of teak defoliators	7.0
8.	Establishment of three more centres under marine organism scheme of the Wood Preservation Branch, F. R. I., Dehra Dun.	3.0
	TOTAL A_3 :	101.1

1	2	3
	A$_4$: Farm Forestry and Range Management	
S$_2$G$_1$A$_4$P$_1$.*	Studies on wind breaks and shelter belts	100.
2.*	Studies on techniques of improvement of degraded grass reserves pastures, forest grazing ground & plantation areas.	30.
3.*	Survey and assessment of grazing resources of different types of forests and grazing grounds.	20.0
4.*	Determination of carrying capacities of different forest grazing grounds in terms of animal units per unit area.	25.0
5.*	Production and management of tree leaf fodder	10.0
6.	Studies on establishment of wood lots	5.0
7.	Extension and development in farm forestry and range management . . .	10.0
	TOTAL A$_4$	200.0
	A$_5$: Wood Sciences	
S$_2$G$_1$A$_5$.P$_1$.*	Preparation of design data for plywood, hardboard, particle board, sawmilling and wood-working machinery.	4.7
2.*	Extension of punched card method for field identification of lesser known species of timber	6.2
3.*	Improved methods of natural seasoning of timber and timber products . . .	5.5
4.*	Development of particle board for tropical climate	7.7
5.*	Retrieval of wood residues from forests and factories	2.5
6.*	Establishment of Indian Institute of wood science	100.0
7.*	Development of economic methods for protection of logs and wood chips from decay, insect attack and deterioration.	5.0
8.*	Development of grading techniques for logs and converted timber	6.0
9.*	Ultra-structure and histochemistry in relation to wood properties	16.0
10.*	Chemical utilisation of wood including bark for establishing chemical industries . .	5.0
11.*	Development of non-destructive tests for strength, decay, insect attack and quality control of timber and timber products.	11.20
12.*	Development of glulam structural units from hardwoods	3.5
13.*	Utilisation of less used species and exotics and small diameter logs for plywood and other industries.	9.0
14.*	Development of wood-plastic composites	2.3
15.*	Design and development of cooling towers with timber and timber products . . .	4.3
16.*	Development of wood cement blocks, panels and slabs for building	10.
17.*	Development of leach resistant and weather resistant fire retardants for wood and wood products.	1.7

1	2	3
	18.* Development of panel products from agricultural residues particularly tannin containing materials.	5.5
	19.* Development of water and weather resistant adhesives for plywood	2.8
	20.* Evaluation and utilisation of Indian bamboos	5.0
	21.* Development of timber engineering techniques	7.0
	22.* Design and development of containers and packages from wood and wood-based panels	8.5
	23.* Durability tests on timber, bamboos and structural plywood on land	5.0
	24.* Research in mechanics of wood-working and saw-milling	5.5
	25.* Dynamic studies on timber and timber products	5.0
	26. Anatomical and physico-chemical methods for specific identification of commercial timbers.	6.2
	27. Fundamentals of flow of fluids and their equilibrium in wood	2.5
	28. Densified wood and wood-based panel materials	5.0
	29. Development of plywood tubes, barrels, tanks etc.	2.5
	30. Techno-economic studies on wood based industries including machinery	5.0
	31. Evaluation of wood quality of man made and natural forests	2.5
	32. Development of wood finishes and methods of their application	2.5
	33. Utilisation of wood based panels in pre fabricated building components	1.3
	34. Design and development of furniture from wood based panel materials	2.5
	35. Design and development of plywood boats for inland and coastal waters	1.2
	TOTAL A$_5$	276.10
	A$_6$: **Pulp and Paper Products**	
S.C$_1$A$_6$P.1.	Development of high yield process for production of paper and paper-board for packaging from indigenous forest based raw materials.	48.0
	2. Development of coated papers for printing from indigenous raw materials	56.0
	3. Grading of hardwoods for pulp and paper industry	75.0
	4, Pilot plant production of hardwoods sulphate pulps and production of papers of various grades on high speed machinl.	220.0
	5. Mechanism of sheet formation	70.0
	6. Utilisation of black liquor	40.0
	TOTAL A$_6$	509.0

A_7—MINOR FOREST PRODUCT

1	2	3
$S_2G_1A_7P_1$*	Minor forest products—survey of resources, markets and industries.	100.0
	2.* Cultivation and exploitation of commercially important medicinl and aromatic plants.	10.0
	3.* Investigations on commercially important gums and gum-resins	7.5
	4.* Investigations on the use of some chemicals for increasing resin yield in Pines	7.0
	5.* Investigations on beedi leaf (diospyros melanoxylon roxb).	2.0
	6.* Menthol from Delta-3-carene, the major constituent of Indian turpentine ex-*Pinus roxburghii.*	5.0
	7.* Investigations on cultivation, exploitation and processing of canes both indigenous and exotic.	4.1
	8.* Investigations on cultivation and exploitation of sisal (*Aqave Sisalana*) fibre.	5.0
	9.* Documentation and dissemination of technical information on minor Forest Products	2.4
	10.* Utilisation of turpentine-exploitation of longifolene/isolongifolene	2.5
	11.* Exploitation of pine wood and pine stumps for the production of Wood, Rosin and Wood-Turpentine in India.	2.5
	12.* Development of Oil seeds of tree origin	2.5
	13.* Essential oil of *Bursera delpechiana* its production and chemistry	3.8
	14. Utilisation of rosin process development on hydrogenated acid modified resins, paper sizes	6.9
	15. Study of variability and Germplasm collection of important Medicinal & Aromatic Plants growing in Arid Regions of Temperate to Alpine Himalayas.	3.5
	16. Increased production of sandal wood and sandalwood oil	3.8
	17. Survey of *Eucalyptus citriodora* and production of citronellol	3.8
	Total A_7—:	172.3

A_8: Harvesting and Extraction (Logging)

$S_2G_1A_8$.	P1.* Logging and operational efficiency research project	50.3
	Total A_8 :	50.3

1	2	3
	A_9— Wild Life	
$S_2G_1A_9P_1$.*	Determination of the best method of censusing populations of important wild life species.	30.0
2.*	Wild life research and education wing at the Forest Research Institute & Colleges, Dehradun.	15.0
3.*	Study of the ecology & management of endangered species	30.0
4.*	Study of the inter-relationship between domestic livestock and wild life . . .	10.0
5.*	Study of the influences of forestry practices on wild life	5.0
6.*	Ecosystem analysis of Gir forest and ecology of wild life therein	7.0
7.*	Studies on the biology of the Mahseer (Tor putitora)	2.5
8.*	Establishment of breeding pens and game farms in the wild life sanctuaries and national Parks	10.0
9.	Establishment of Native Preserves in selected areas of the Rann of Kutch for the Flamingo and the Indian Wild Ass.	6.0
10.	Establishment of central wild life Research Institute	20.0
	Total A_9 :	135.5
	A_{10}—Land Use	
$S_2G_1A_{12}P1$.*	To evolve suitable landuse practices for different classes of marginal lands and waste lands consistent with sustained maximum production from such lands.	100.0
2.*	Establishing Centre Land and water Conservation Research and Training Institute .	200.0
	Total A_{10} :	300.0

1	2	3

A_{11}—Watershed Management and flood control

$S_2G_1A_{11}P1$.*	Hydrologic response studies on small watershed under existing and introduced land use variations	
2.*	Evaluation of climatic, physiographic and land use parameters affecting gross erosion in various land resource regions and areas	300.0
3.*	Integrated pilot projects to investigate the effect of land and cover management with structural means including micro reservoirs on hydrologic response of the watersheds.	
4.*	Development testing and fabrication of small watershed hydrologic instruments/equipment and control structures.	
5.*	Water harvesting and waterbudgetting studies and identification and amelioration of drought prone areas.	25.0
6.*	Survey and collection of data on flood affected agricultural, grass and marginal land for problem genesis and prevention feasibilities of flood hazards	75.0
	Total A_{11} :	400.0

A_{12}—Soil and Soil Plant Relationships

$S_2G_1A_{12}P_1$.*	Forest soil-cum-vegetation survey	79.0
2.*	Nutrient and fertilizer requirements with special reference to man-made forests	30.0
3.*	Diagonosis and improvement of problem soils in forest Areas	3.0
4.*	Development of soil suitability indices for important forest plantation crops	3.0
5.*	Plant-water-soil relations with regard to growth and development of forest species and type.	26.0
6.*	Studies on the effect of fertilizer application on soil characteristics and water quality	7.0
7.*	Study on the status of micronutrients in different forest soils	3.0
8.	Microbiological population in soils under different forest types and their role in the release and uptake of nutrients.	3.0
9.	Standardization of soil tests for soil-climate-forest species association	2.0
10.	Mineralogical composition of forest soils under different pedegenetic conditions and rate of release of Plant nutrients in the root zone.	9.5
11.	Effect of clear-felling and plantation of soil properties	2.0
	Total A_{12}	167.5

Asterish denote priority I projects in order

HIGHLIGHTS OF IMPORTANT R&D PROJECTS

Studies on Introduction of Important Exotic Tree Species including Seed Procurement.

Exotics play extremely important role in the augmentation of the wood resources of a country. In many countries the wood-based industries are mainly dependent on the plantations of exotic species.

Trials with exotics are being conducted in the country and with certain species some experience has also accumulated. Eucalyptus tereticornis (Mysore gum) is being planted on a large scale. E. grandis finds an important place in plantation programme of the hill grass lands of Kerala and in Tamil Nadu. Cryptomeria plantations have been raised in West Bengal for long. There has also been some activity in raising trials of tropical and other pines and conifers in various parts of the country.

In this project certain prospective zones will be selected in each state and representative areas in each zone marked. The seeds to be obtained will be indented keeping in view the various zones in states. For certain species like Eucalyptus tereticornis & E. camaliulensis the trials will have to be on provenance basis, so also for species like Pinus patula where preliminary suitability trials have established it as promising. For others the range sampling phase has to be gone over and for some donor regions the preliminary elimination phase trials will have to be done. Further, it is also envisaged to send seed missions to countries like Australia and Mexico for collection of seed and identify the provenances which may prove useful.

Establishment of a Data Processing Centre at F.R.I.

Raw data collected in field trials is of no use, unless it is properly processed to give meaningful results. Data processing is now a very specialised field. Field workers capable of processing the data are also rare. Since factors influencing growth in forestry are many it is very difficult to get proper results with conventional methods of data analysis. Vast research in Agriculture and other scientific fields has been possible because of quick analysis of observations by modern techniques of data processing on fast computers. Forestry research in India has lagged behind because of non-availability of personnel and equipment to analyse the field data quickly and properly.

In this project it is proposed to undertake the following:

(i) Data collected in various other projects or schemes will be analysed.

(ii) Forms for collection of data will be standardised.

(iii) Programmes for various forestry jobs will be prepared.

(iv) Programme for documentation works will be prepared and actual operations will be done.

All-India-Centre-cum-States Coordinated Project for the Genetic Improvement of important forest tree species.

The main objective of this All-India Project will be to initiate work in production of pedigreed seeds in all important tree species. This calls for selection and hybridization work similar to what has been going on in the field of crop-plants.

The plan of work envisages such work being initiated in selected conifer and broad-leaved species. Where necessary, inter-provenance hybridization and interspecific hybridization will be resorted to. Seed production areas will be established to meet the interim needs of seeds of known origin by survey of the existing stands, identifying the best stands and treating them for seed production. This treatment involves removal of inferior phenotypes, crown thinning, fertilizer application where necessary, etc. A register of seed stands will be maintained and seeds of only those registered stands will be used in all future plantation programmes. Clonal seed orchards for all the important species will be established by using scions for grafting from superior phenotypes (plus trees). This is the best publicised and most widely practiced method of mass production of pedigreed seeds in forestry. Progeny trials will be established and evaluated to assess the breeding value of the plus trees for use in the second cycle seed orchards. Species of All-India importance like teak and eucalyptus amongst the broad-leaved species and some species of regional importance, both coniferous and broad-leaved. are proposed to be taken up under this project.

Forest Productivity.

The rising demands of forest raw materials coupled with the low productivity of our forests has caused India to be classified on the world map of forest resources as belonging to a "deficit zone". Comprehensive studies on forest productivity have therefore, become essential in view of increasing the productivity from our limited forest area including raising large scale plantations and conservation of the environment. The scheme therefore envisages to get an estimate of potential (economic) productivity of natural forests, and biological productivity and nutrition cycling in natural forests and plantations.

Under the studies on potential (economic) productivity of forest areas, it is possible to calculate the potential productivity of different forest regions of the country from easily ascertainable climatic indices with due allowance for soil and other factors. In these preliminary short term studies it is proposed to delimit the different forest productivity zones, in different states. The average productivity of each productivity zone for each state would then be calculated and compared with actual production from well-managed natural forests, sample plots and plantations in each region. At a later stage soil and biotic variables would be introduced to get more realistic estimates of productivity.

With regard to biological productivity and nutrition cycling aspect, suitable representative sites will be selected and the methods of studying biomass and productivity standardized. Field data would be collected on biomass and productivity and plant samples collected for laboratory analysis, and nutrition uptake. Concurrently litter samples will be collected periodically to find out the total annual litter fall and amount of nutrients returned to the soil. For purposes of comparison representative sites will be selected in adjacent natural and man-made eco-systems.

Survey of insect pests and diseases and their control.

Pests and diseases take a heavy toll on forest wealth through out-right killing of trees or through reducing the quality and usefulness of wood produced or through impact on growth. On a rough estimate, the loss is about 13 per cent as revealed from 1953 timber trend studies for India. The object of the survey is to determine the cause, evaluate the status of pests and diseases, determine their actual and potential threat, assess damage, study factors leading to epidemices and take timely action to organise control and thus maintain the health of forests. During the Plan Schemes, a sum of approx. Rupees Two Thousand million was invested for forest development projects. A major part of this expenditure was utilized for raising plantations mostly of pure crop. The pest and disease hazards in such plantations are high and in extreme cases may threaten the success of the plantation *e.g.*, eucalyptus in Mysore and Kerala states and thus seriously disturbing development plans. Such calamities can be averted if simultaneously adequate funds are earmarked for protection.

The project will be coordinated from the head-quarters at Dehra Dun where the main research in Entomology and Pathology is being carried out. Five survey units will be engaged on the work in the field. The plan of work for headquarter and for each survey unit will be as under:

Headquarter (Dehra Dun).

1. Preparation and periodic review of survey manuals based on field experience.
2. To provide guidance and coordinate research between different centres.
3. To provide regular orientation courses for the field staff in the project.
4. Identification of forest insects and pathogens collected during surveys. This work is possible only at Dehra Dun as there are well established herbarium and insect collection for reference. Also library and other facilities exist at Headquarters.
5. To collect data received from field stations and issue consolidated reports.
6. To prepare annotated list of pests and diseases.
7. Organise Annual workshop.

For each of the 5 zonal centres.

1. To conduct disease and pest surveys, determine status of prevailing diseases and pests, investigate factors predisposing plants to diseases and pests and assign priorities to projects for conducting detailed investigations.
2. To determine the impact of diseases and pests on growth and evaluate losses both qualitatively in case of out-right killings or retardation of growth and quantitatively in case of decays and discolourations.
3. To lay out trial experiments for control, evaluate the efficacy of different control measures and recommend the feasible control practices.
4. To render technical help and supervise control programmes to be carried out by the state forest departments.

Studies on Sandal Spike disease and its control.

Several plant diseases known as yellows type of diseases, were earlier considered to be due to viruses. Recently evidence has been obtained that these diseases are probably caused by another group of organisms called mycoplasmas and not by viruses. In sandal, also, mycoplasma is associated with spike disease. This finding is of great significance as it has raised hopes for its control through use of broad spectrum chemicals, antibiotics, and also controlling insect vectors disseminating the disease.

In this project it is proposed to undertake the following :

(i) Complete survey of sandal forests to determine the extent of infection of sandal and also of side hosts.

(ii) Detection of mycoplasma like bodies by electron microscopy of diseased tissues and examination of mycoplasmal activity by stain technique.

(iii) Identification of various insects frequenting sandal in diseased areas and also healthy trees.

(iv) Confirmation of insect vector/vectors and their control.

(v) Techniques of culturing of diseases agent and its identification.

(vi) Epidemiology of the disease.

(vii) Control of the diseases caused by mycoplasma by chemical treatments.

(viii) Breeding disease resistant varieties.

(ix) Development of immunofluorescent technique for detection of mycoplasmas which will help in easy detection of infection.

Studies on wind breaks and shelterbelts.

The objective of the scheme is to provide scientific data on the basic requirements for wind breaks and shelterbelts for suitability of species in different types of climate with respect to rate of growth ; degree of competition with agricultural crops, structure and disposition of wind breaks, protective aspects like soil moisture and protection from descicating winds, pruning intensities of tree species, and the economic aspects of influence of wind breaks on crop yields. The scientific investigations on these aspects of wind breaks and shelterbelts for Indian conditions are essential so that the choice of species and raising of wind breaks and shelterbelts is based on proper scientific basis to achieve best results.

The following research investigations will be undertaken in this project :—

(i) Studies on suitability of tree species, technique of planting and measures to increase rate of growth *e.g.* application of manures and fertilisers, pruning regimes, rate of growth of various species, root competition, utility for fodder and small timber, intake of nutrition by tree species. These studies will be carried out for wind breaks and shelterbelts and tree plantation in roadsides, canal bank and railway lands in different types of soils and climatic conditions.

(ii) Studies on structure and disposition of wind breaks and shelterbelts. In these studies, the spacing of the species in and between lines, number of rows, structure of the wind break and shelterbelts, and their disposition will be taken up.

(iii) Influence of trees on soil temperature, soil moisture, prevention of shifting sands, wind velocity with respect to wind breaks and shelterbelts, canal bank plantations and tree avenues, effect of tree canopy on pathogenic fungal and insect population.

(iv) Influence of tree canopy on agricultural yields, intake of soil nutrition by trees.

(v) Economic aspects of raising wind breaks and shelterbelts, canal bank plantations, road-side avenues.

Studies on technique of improvement of degraded grass reserves, pastures, forest grazing ground and plantation areas.

Under the present practice of unrestricted grazing the forest grazing grounds have deteriorated beyond improvement. The grazing lands are rendered almost unproductive and they are monopolised by unpalatable, inferior and coarse grasses. Under the pressure of excessive grazing these areas are heavily eroded or liable to erosion resulting in wash off of productive soil. The improvement of such grazing lands would involve restrictions on grazing and undertaking active improvement measures. This involves heavy capital expenditure. In absence of precise knowledge of ways of improving vast grazing lands, it is necessary to undertake elaborate investigations on improvement techniques of grazing land pastures and grass reserves. It is proposed to initiate investigations on all aspects of effects of grazing, rotational and differed grazing, soil working, manuring and regeneration by reseeding etc.

Studies on the improvements of degraded (i) grass reserves (ii) pastures (iii) forest grazing grounds and plantation areas will be undertaken with respect to rotational and differed grazing, soil working, manuring and regeneration by seeding.

Preparation of design data for plywood, hardboard, particle board, sawmilling and wood-working machinery.

Restrictions on the import of plywood and other woodworking machinery were imposed recently with the result that necessity to make these machines in our country is felt both by the Government and the industries concerned. The manufacture of these machines is beyond the scope of small scale units, and new factories to manufacture exclusively these machinery are not likely to come up because of the irregular demand. Therefore some of the already well established units should take up the manufacture of these machines. It is estimated that in the next 5—8 years plywood industry alone will be requiring 40 peeling lathes costing nearly 2.5 crores and 50 hydraulic hot presses costing about 5.0 crores of rupees.

In this project it is proposed to prepare detailed design data for (1) peeling lathes and hot presses required by the plywood industry and (2) specialized woodworking and sawmilling machinery. In the second stage design data for plywood machines such as dryer, glue spreader, jointer, knife grinder, D. D. Saw, etc. and machinery required by particle board and hardboard industry will be taken up.

Extension of punched card method for field identification of lesser known species of timber.

Use of wrong timber out of ignorance or as a result of fraud is often the cause of incalculable loss of material, money and even human life. Such wastage both in public and private sectors can be avoided or reduced to minimum, by ensuring the use of correctly identified timber. With the increasing demand for timber for various industrial uses, and scarcity and high prices of the well-known timbers more and more secondary species are coming to the market. The various I.S.I. specifications now cover well over 300 species and it is expected that this number will go up still further. There is, therefore, an urgent necessity to extend the card key to all tree species occurring in India.

The card key has already been designed and developed at the Forest Research Institute, Dehra Dun in collaboration with Indian Standards Institution, New Delhi. But data for the preparation of the cards have been collected for only about 50 species so far.

It is proposed to examine all the wood samples available in the Xylarium of the Forest Research Institute for studying for variations in physical characteristics and anatomical features of all the Indian species. The information collected will then be classified and summarized for the preparation of the card key. It will also be necessary to collect authenticated wood samples of those species which are not represented or are inadequately represented in the Xylarium at Forest Research Institute.

Minor Forest Products—survey of resources, markets and industries.

Some work on a few minor forest products is being carried out by different organisations. Among these, mention may be made of minor forest products in F.R.I. and work on oil seeds in the Directorate of Oil Seeds, Hyderabad, medicinal plants in the Ministry of Health, spices in the Plantation Crop Research Institute, Kerala. However, owing to the vastness of minor forest products and varied nature of the problems, the present facilities and efforts are far from being adequate. The work related to field trials, survey of forests, markets and industries has to be carried out in the states/regions where they are located. The state forest departments are already fully occupied with the programmes of their own. With the result, the minor forest products are not receiving the required attention.

The coverage of study will be the whole country, which for convenience will be split into 22 centres in 21 states/territories grouped into the 4 zones *viz.*, (i) Northern—U.P., H.P., J&K and Bihar, (ii) Western—M.P., Maharashtra, Gujarat, Rajasthan, Punjab & Haryana; (iii) Eastern—Bengal, Assam, Arunachal, Meghalaya, Mizoram, Nagaland, Manipur, Tripura and Andaman & Nicobar Islands; (iv) Southern—Orissa, A.P., Mysore, Tamilnadu & Kerala. One central unit will be located at the Forest Research Institute Dehra Dun. The work on oil seeds of forest origin will be implemented by the FRI, in collaboration & coordination with the Directorate of Oil Seeds Development, Hyderabad, which has also put up a separate scheme on development of oil seeds of tree origin.

Indian minor forest products of vegetable origin are derived from over 3000 plant species. To carry out investigations on such a vast number of species is a formidable task. Consequently emphasis will be laid on more important species which have been identified for each state. The studies will comprise:—

Distribution, availability (present & maximum potential); method of collection, processing, grading, packing & storage; quality according to season, method of collection, locality, varieties and forms, adulterations and sophistications; scope of demand, trade and utilization *i.e.*, comprehensive study of markets, industries and factors governing demand and supply; measures for increasing production and utilization, supplying raw materials of standard quality to trade and industry.

Cultivation and exploitation of commercially important medicinal and aromatic plants.

Although India is rich in medicinal and aromatic plants, a number of these are imported. Many of the indigenous products are not adequate to meet the demand for internal consumption and export trade. This is chiefly due to lack of systematic and scientific know-how to augment production of these both quantitatively and qualitatively. If this is done, India will not only achieve self sufficiency in these products but will also have enough surplus to earn valuable foreign exchange through exports of raw materials and their products. This project, therefore, aims at developing systematic and scientific know-how for most economic and efficient cultivation and exploitation, together with improving productivity and quality of planting stock and raw materials, of both indigenous and exotic.

For planned economic development and to achieve increased production of medicinal and aromatic products, researches are required to be carried out under most favourable climatic and edaphic conditions for individual species, which are specific and varying in their requirements. Therefore, cultural experiments will be undertaken at different places with varying climate and soil conditions. This is more so in case of exotic species. For this, six centres in the different regions of country *viz.*, at Raipur (M.P.), Kodaikanal (Tamil Nadu), Chandrapur (Maharashtra), Baramulla (J&K), Nongpoh (Meghalaya) and Dehra Dun (U.P.) will be established. At each of these centres, work on the medicinal and aromatic plants of the area and adjoining states will be undertaken.

Logging and Operational Efficiency Research Project.

Logging is a labour intensive operation and bulk of about Rs. 200 crores is spent annually in India on harvesting of timber (which is about 60% of the total expenditure on forestry operations including administration and growing of forests) goes to the labour as wages. At the same time, logging operations involve high energy consumption of the workers (nearly 600 Kilo Calories per hour as against about 300 Kilo Calories in case of other industries).

Over bulk of the area, primitive harvesting methods are employed which involve huge wastage of timber (worth about Rs. 200 millions annually). Modern logging techniques help in minimising wastage of timber and give better output with lesser energy consumption—thus increasing the earning capacity of the workers and their physical and economic well-being. The main reasons for non-adoption of these techniques in the field are non-availability of the improved tools and machines in India, lack of sufficient data on statistics and economics and proper extension work.

Research will be carried out in the following fields.

(i) Designing and fabrication of prototypes of new tools and machines from nursery to felling and transportation stage (the designing and fabrication of nursery and plantation machines have also been included in this project to achieve the maximum machine utilisation and to take advantage of the mechanical talent that will be available).

(ii) Conducting time and cost studies on the working of various tools and machines.

(iii) Conducting physiological studies on the efficiency of various tools and machines.

(iv) Carrying out economic investigations with regard to present and proposed logging techniques, with special regard to transport economics.

(v) Conducting studies in saw-milling.

In addition to the above, field demonstrations will also be arranged to some extent, as and when required.

Determination of the best methods of censusing populations of important wild life species.

Very little information is available on the populations of different wild life species even in the National Parks and sanctuaries, leave alone in the entire forest area in the country. Efforts have been made to census some important species in Betla (Bihar), Kaziranga (Assam), Corbett (U.P.), Kanha (M.P.), Gir (Gujarat), Sariska and Bharatpur (Rajasthan): but these sporadic attempts have given mere indications of numbers of different species in the areas censused and have to be followed up at regular intervals to determine the population dynamics. The census work would be conducted in the following 15 states :

Andhra Pradesh

Assam

Bihar

Gujarat

Haryana
Himachal Pradesh

Uttar Pradesh

Kerala

Madhya Pradesh

Maharashtra

Mysore

Orissa

Rajasthan

Tamil Nadu

West Bengal.

For this purpose each state will appoint the necessary staff to augment the existing personnel in the Wild Life Organisations of the State Forest Departments. There will be a Chief Coordinator for each State and local labour would have to be recruited from time to time after determining the best season to census different species. It may be necessary to census the same area twice a year to obtain the population dynamics during different seasons. The work would eventually have to be continued on a long term basis to determine the effect of different levels of management and their effect on wild life populations.

The species which will be censused under the project will be as follows:

1. Elephant
2. Gaur
3. Buffalo (in Peninsular India)
4. Sambar
5. Cheetal
6. Hog deer
7. Panther
8. Caracal
9. Four horned antelope
10. Muntjac.

(*N.B.*—Census of tigers and Rhino will be continued as they are being done at present).

Wild life Research and Education Directorate at the Forest Research Institute and Colleges.

There is an urgent need for research in the field of wild life to determine how best we should manage, this important renewable resource and utilize the land to its optimum. So fa very little has been done in this field except for sporadic and individual attempts by variou foreign and Indian enthusiasts. With the drastic decrease in the number of wild life species an the strong linkage between tourism and wild life, many states have now set up wild lif organisations within the State Forest Departments. These Organizations are now being called upon to conduct the census of various important wild life species, determine optimum levels of populations, and competition between domestic and wild life-stock etc. Each state will be undertaking these tasks but they must have adequate trained staff to conduct these operations. At the same time, there is an urgent need to develop indigenous objective methodology in conducting various research programmes based on the knowledge gained in other countries but adapted to Indian conditions and wild life species. The proposed wild life research and education directorate at the Forest Research Institute will work in this direction and give the necessary assistance to the States in training their personnel in this field and in giving them guidance in adopting the correct methodology in collecting data for scientific wild life management. The Directorate will also collect, collate and analyse data and maintain documentation on wild life research and development.

In this project it is proposed to:—

(i) Evolve standards, methodologies for better coordination in integrated wild life management.

(ii) Codify and document the literature and data.

(iii) Determine the best management of various gradients of human influences including domestic livestock and their effects on wild life.

(iv) Guide the States in the study of habit formations.

(v) Study the measurement of behaviour and adaptability of wild animals and birds to varying conditions of habitat management.

(vi) Determine nutritional levels of forage seasonal productivity, availability and actual use-factors.

(vii) Assess the economic productivity in various combinations of plants and animals for increasing multiple returns without deterioration of essential qualities and properties of the ecosystem.

(viii) Conduct training courses in wild life management for various cadres of personnel interested in and working on wild life management.

To evolve suitable land use practices for different classes of marginal lands and waste lands consistent with sustained maximum production from such lands.

Out of the total land area of 305.9 m. ha. of the country, an estimated 56.9 m. ha. *i.e.* 19% of the area is in the category of culturable wastes, pastures and fallow lands. Large part of these lands are cultivated at intervals and support only marginal agriculture. Those that are not cultivated also support only very poor quality of pasture or are barren. The production from such lands does not even meet the cost of efforts and inputs which the farmer puts in them. Such lands exist in the hilly and the sub-hilly areas of the country which are inhabited largely by the weaker section of the community. The economic and social backwardness of the population prevents introduction of any new ideas involving investments and violent change of practices. A vicious cycle thus sets in making the people poorer. Unless therefore, the vast areas of marginal and sub-marginal lands are put to economic uses for production, the condition of the farmers of these zones is not going to improve. These areas also happen to lie in the major water-sheds of the country. These marginal and sub-marginal lands, because of their faulty land use pattern, create related problems of sedimentation and floods in the command areas.

Large scale plants for dairy and animal husbandry development cannot be prepared and executed mainly due to shortage of fodder. The marginal lands and waste lands, which were used as grazing lands in the past but have been put to uncertain agricultural use in the wake of the recent "Grow more food campaign", will have to be reverted to growing of fodder to meet the growing needs of dairy and animal husbandry. Incidently this will also be the most economic use for such lands.

The bulk of the energy supply of the country comes from fuel wood. The sources of supply of fuel has been fast dwindling. The marginal land and waste lands could be profitably utilized for raising quick growing fuel and small timber species for the rural population.

A considerable part of the marginal and sub-marginal lands can be used for growing horticultural crops. Such crops will be much more paying than the uncertain agriculture being practised on such lands.

An assessment of the extent of marginal lands and waste lands will be made from the data already available with different Central and State Agencies for a realistic estimate. Development Projects will be set up in each class of land in different problem areas of the country so as to evolve the best alternate land use. The alternate land use will, of course, take into consideration the fact that it gives the maximum net return in the quickest possible time. The assessment of problem areas will be done in the first two years of the period of the project. Development sites will be taken up in the whole country so as to test and evolve different alternative land use patterns. Each development site should be taken on watershed basis and located in representative problem areas so that the results obtained can be widely applicable. The different land use practices like fodder, fuel wood species, horticultural crops and some special types of agricultural crops will be tested on the development sites on the basis of information already available. Complete data will be maintained so that full conclusion regarding cost benefit ratio can be drawn. It is realised that unless the cost benefit ratio is highly favourable the farmers are not likely to take to the recommended land use pattern.

Hydrologic response studies on small watersheds under existing and introduced land use variations

Selected watersheds will be located in the areas after consulting the Land Resources Regions Map (Soil Conservation Research Demonstration and Training Centre, Dehra Dun) and Water Resource Regions Map of Central Water and Power Commission. The incremental gauging will give the variations in hydrologic responses of complex or multiple sources. Whereas, through comparison between the responses of existing and treatment introduced source areas, the effect of various introduced practices will be evaluated. The aspects should cover:

(i) Sources under various land uses as existing. The responses of the unit and multiple sources will be taken as references.

(ii) Important silvicultural systems and related forestry practices.

(iii) Biotic influences such as fire, grazing, logging, lopping, etc. etc.

(iv) Over grazing, burning of the grass land.

(v) Shifting cultivation.

(vi) Bunded and benched agricultural land-paddy and non-paddy.

(vii) Trenched plantations of tea and coffee.

(viii) Orchards.

(ix) Afforested lands.

(x) Control structures for gully, ravine, etc.

The field data [(a) climatological, (b) hydrological, and (c) physiographic] collected by each of the watershed units, will be processed, documented and analysed (statistically, by hydrograph component analysis and by watershed models) at the Regional Centres.

Water harvesting and water budgeting studies and identification and amelioration of drought prone areas

At present the definition and identification of drought events are based on rainfall data or rainfall evaporation ratios. The soil moisture storage, physiography, cropping details and water use development are not yet incorporated into such attempts. Even though the drought hazards are being realised, work for alleviation has not yet taken the potentialities of collecting, storing and using of limited rain water for overall development. It is now known that the areas subject to frequent flooding are often put to water stress resulting in failure of crops, etc. The relationship of the water harvesting schemes to the flood hazards has not yet been examined. The Soil Conservation Research Demonstration and Training Centre have been engaged in some sporadic projects and the dry farming project has a few basically agronomic schemes.

The role of water balance particularly, and hydrology in general, as well as the engineering techniques such as micro reservoirs etc. have not yet been evaluated.

The projects would be taken up at selected regional centres, where small scale, controlled studies will be taken up on plot as well as on lysimeter. In these plots and lysimeters complete water budgeting studies should be done from which, and in the context of the prevalent climate and soil, most rational land use practices for each of these regions, limited by overall water resource position will be evolved. The small experimental studies for development of water harvesting techniques will also be taken up so that the entire project becomes practical and utility oriented. Small reservoirs also will be studied for collection, storing and rousing the precious rain-water for better return. The climatic data along with the crop performances will be helpful in detecting drought hazards (Agricultural) whereas the quantum of water collected and stored will give other aspects of drought (i.e. hydrologic).

Forest Soil-cum-Vegetation Survey

The main purpose of this scheme is to carry out comprehensive soil survey of the forest areas of the country with a view to ultimately delineating various productivity zones based on soil characteristics coupled with climatic and other factors including correlation with existing vegetation. Each soil has a definite range of attributes with respect to its potentiality to sustain vegetation. The vegetational study included in this scheme will therefore be of this specific objective where forest vegetation could be used as indicator of various soil types so that soil survey results will lend themselves to easy practical application in the field..

This survey will also be useful in understanding the relationship and distribution of various soil and vegetation types in different forest areas of the country. Foresters in this country are becoming increasingly aware of the importance of understanding of soils and their relation to growth, stand composition, other factors affecting productivity and optimum forest potential. Even the incidence of certain forest diseases, is related to certain groups of soils. Each soil has a definite range of performance and potentiality and in dealing with any problem having a bearing on soil conditions, it is an essential prerequisite to recognise the kind of soil involved. The survey will make possible the synthesis of the results from research and from experience and the orderly application of the available knowledge in forestry in much the same way as in farm management.

The work in the project will be carried out with the following two objectives :

(i) To identify the inherent fertility status of soils of different areas representing different conditions of soil, climate and vegetation to locate problem areas and marginal lands.

(ii) To find out quantitative scientific relationship between the nature of the soil and forest growth.

At each of these centres, there will be a Soil Correlator under whom there will be two field parties to carry out the survey of soil and forest vegetation simultaneously. Typical soil profiles under specific forest types and species will be examined in the field, and laboratory examination of the profile samples will be carried out according to the standard procedures. Soils will be classified accordingly and soil associations identified . The percentages of different species in a forest type, and the density of growth of the vegetation will be determined by the ecologist with standard procedures. Ordinarily, with the help of aerial photographs, in the scale 1:25,000, one field party will be able to cover about 500 ha. in a day carrying out simultaneously soil and vegetation survey. The priority of the forest area to be surveyed will be drawn up in consultation with the State Forest Departments. The Silviculturist of the concerned states will be fully associated with the project in drawing up the plan of work and interpretation of field data.

Nutrient and Fertilizer Requirements with Special Reference to Man-made Forests

Large areas undoubtedly marginal in character, are being taken up for afforestation specially with fast growing short rotation species like Eucalyptus. Many of these sites do not have besides other things, sufficient quantities of nutrients to support good and sustained forest growth. These mineral deficiencies have to be corrected to make these areas fit for better production. Also, as the plantations raised in such areas have to be economically viable producing an optimum yield in a fixed period, it is all the more necessary to have mineral deficiencies corrected in such plantation areas

The work will be started with important afforestation species. It will include the work on determining the initial nutrient status of the soil, fertilizer requirements, time and methods of application, at the time of formation of plantations as well as in older plantations. Annual observations on survival, height and diameter growth etc. would be made in these plantations. Experiments would also be conducted on foliar application of fertilizers.

Subsector: OIL AND NATURAL GAS

A. *Introduction*

Petroleum is a strategic mineral which finds its extensive use in transport, defence and chemical industries which include fertilizers, plastics, synthetic rubbers, fibres and pharmaceuticals. In order to meet our country's demands for petroleum in the various sectors of the economy, it is necessary that the stock of petroleum and natural gas be known for further exploration and exploitation of oil.

Exploration and exploitation of oil is based on considerable amount of data obtained by different lines of investigations. An intelligent analysis and synthesis of both on land and offshore data obtained by different scientific and technological studies ultimately leads to the discovery and production of oil and natural gas.

B. *Present Status*

India has 1.03 million sq. kms. of sedimentary areas spread over 26 basins on lands and these offer prospects for occurrence of oil and gas. The offshore continental shelf along the Indian coast covers approximately 0.26 million sq. kms. About 23,000 kms. line has been covered by seismic work in off-shore and a number of potential structures have been delineated in the Arbian Sea adjoining Gulf of Cambay. Various provinces have been established in Western India, and other parts of the country. Oil and Natural Gas Commission has done commendable work and its current production is of the order of 4 million tonnes per year. The Oil India Limited and Assam Oil Company Limited, together are producing about 3 million tonnes per year, thus bringing the total oil output in India to about 7 million tonnes per year. Our present requirement of petroleum is of the order of 20 million tonnes per year. The projected demands for petroleum and petroleum products is likely of the order of 40 million tonnes by 1980-81.

This position clearly brings out the need for greater inputs into our efforts in exploration for oil and to increase indigenous production thus avoiding severe drain on foreign exchange reserves. Also alternative fuels and feed stocks should be maximised. Apart from its uses as an alternative fuel, petroleum is a basic feed stock in fertilizers. An early policy decision is therefore, relevant in the overall development of petroleum industry. The concept of the "Chemical Refinery", which is supposed to generate its own optimum level of the feed stock to meet the requirements of the entire petro-chemical complex built around it, is also worthy of consideration. Conversion of solid fuels to liquid fuels like coal to oil also has to be explored.

The recent techno-economic feasibility study of oil production in India has indicated that by increasing the tempo of the exploration and developmental operations, the ONGC can increase its production from 3 million tonnes to about 8 million tonnes in 5 years time and to about 18 million tonnes in 10 years.

Government of India has so far invested about Rs. 133.2 crores upto March 1972 and ONGC has discovered 108.6 million tonnes of primarily recoverable oil and 12.8 million cubic meter of gas and has generated a revenue of Rs. 102.83 crores with remaining recoverable reserves equivalent to Rs. 927.56 crores. After deductions of taxes, royalties, material operating costs (other than depreciation interest) the next receipts from the balance of recoverable reserves is likely to be Rs. 456.51 crores at current prices.

26 sedimentary basins have been delineated in India. These basins cover an area of 1,67,000 sq. km. including about 26,000 sq. km. in the off-shore areas. So far exploratory drilling has been carried out in seven basins and 93% of meterage has been drilled in the Cambay and the Upper Assam basins and only 7% in rest of the basins. Only 30% of the area has been covered by exploratory drilling.

So far, ONGC has discovered 24 oil fields, and 6 gas fields and has established recoverable oil reserves of over 100 million tonnes. The off-shore operations have commenced with arrival of mobile, self-propelled, self-elevating, off-shoring drilling platform acqired from Japan This will be a major break-through in Indian oil industry.

The exploration, extraction and transportation of petroleum and natural gas have undergone great technological advances in the past decade, especially in regard to off-shore sources and their transportation by means of pipelines and large tankers and in the case of gaps, with the application of liquefaction. The techniques for the utilisation of oil shale have also been greatly improved. It is expected that the technical and economic advancements in these areas will produce far reaching impact on the energy economy of India, if applied wisely. Though India's oil industry is quite old, it has not significantly contributed in the form of RDD activity, till the Institute of Petroleum Exploration(IPE) came into existance in 1963. The input into the RDD activity is less than 1 per cent of the total outlay for exploration and exploitation of hydrocarbons in the country. It is hard to quote the exact amount of money being spent by international oil companies on RDD but it is quite evident from the achievement made by the oil industry that a massive investment must have gone into the RDD activity. Keeping in view the above statement, it is felt necessary to invest substantially in RDD and formulate the national oil policy and comitments, irrespective of risks, problems and investments, that whether we strike oil or not through out efforts but at least we may be able to catch up with the state of art that exist in world elsewhere and export the know how as we are doing in case of Iraq.

Alongside the production programme, RDD work relating to design and manufacture of sophisticated equipment, basin evaluation studies, data processing techniques, and marine projects has to be intensified. The IPE of ONGC has to be considerably strengthened towards these goals. IPE does not have any drilling laboratory presently and it is high time that such a facility be created so that the proposed programmes could be taken up in that institute. The know-how develped through RDD in drilling would be extremely useful in mineral and ground water exploration.

C. *NCST Approach*

NCST has formed 7 sub-committees with members drawn from ONGC, Oil India, Ministry of Petroleum, NGRI, Universities, IIT's, etc., to identify gaps in RDD and formulate projects. The RDD plans prepared for the Oil & Natural Gas sub-sector cover almost the entire spectrum of RDD work needed to be done in order to step up our exploration and production efforts as per the projections made and to achieve self-sufficiency and self-reliance as far as possible.

The R&D programmes for oil exploration and production have been covered under seven Sub-committees namely, Origin, migration and accumulation of petroleum. Biostratigraphy, Sedimentary processes and formation of deltas, Exploration geophysics including Well Logging, Drilling techniques and processes, Drilling mud and Oil well cement and production, Reservoir studies and transportation of oil and gas. These sub-committees have identified 141 RDD projects. The estimated cost of these projects during the Five Year Plan works out to about Rs. 1696 lakhs. The sub-committee-wise break-up of funds is shown below :—

S. No.	Name of the Sub-Committee	Financial Outlay (Rs. lakhs)
1.	Origin migration and accumulation of petroleum	142.20
2.	Production, reservoir studies and transportation oil and gas	142.00
3.	Biostratigraphy	219.70
4.	Drilling techniques & processes	153.60
5.	Sedimentary processes and formation of deltas	135.00
6.	Drilling mud and cement	184.50
7.	Exploration geophysics including well logging	719.00
	Total	1,696.00

The projects identified by the sub committee are given below

Project Index No. $S_iG_jP_i$	Title of the project	Financial Outlay (Rs. lakhs)
1	2	3
	A_1 : Origin Migration and accumulation of petroleum	
$S_2G_2A_1P_1$	Study of hydrocarbon seepages to identify source rocks of petroleum in Punjab, Ganga, Cauvery, Bengal, Godavari-Krishna, Assam and Andaman-Nicobar basins.	25.00
2.	Geochemistry of dispersed sedimentary organic matters of tertiary and pretertiary sequences of poorly explored sedimentary basins of India for evaluating petroleum generating conditions and petroleum source-quality (Punjab, Ganga, Rajasthan, Sanchor, Vindhyan, Godavari-Krishna, Palar, Andaman-Nicobar Basin and Gondwana Grabens).	10.00
3.	Study of relations between chemical composition of crude oils in the Cambay and Upper Assam Basins with geology as clue to their origins.	16.00
4.	Structural and palaeo-structural analysis of all Indian sedimentary basins to determine conditions of hydrocarbon accumulation and period of entrapment of petroleum.	16.00
5.	Hydrogeological and hydrochemical studies of all Indian sedimentary basins in relation to hydro-carbon migration, entrapment conditions and preservation of oil, gas accumulation.	12.20
6.	Study of petroleum and coal association in the Cambay and Upper Assam basins and its significance to evaluation of other coal bearing basins of India.	5.00
7.	Hydrocarbon prospects analysis of Rajasthan, Punjab, Ganga, Cauvery, Bengal, Godavari-Krishna, Mahanadi and Andaman and Nicobar basins from geological, geophysical and geochemical considerations.	15.00
8.	Studies on thermal and thermocatalytic transformation of kerogen in the petroleum generation process and the value of study of kerogen for source-rock identification and for predicting the possible nature of crudes, taking kerogen of the Eocene shales of the Cambay basins as an example.	5.00
9.	Development of computer softwares to study processes of origin, migration and accumulation of petroleum in Indian sedimentary basins.	5.00
10.	Studies on the alteration of crude oil by microbiological, thermal, thermo-catalytic and hydrochemical processes with special reference to problems of migration in Upper Assam and Cambay basin.	15.00
11.	Study of biological markers in petroleum and sediments in the Cambay and Upper Assam basins and evaluation of their applications to the solution of problems of identification of sources and genetic correlation and migration of crudes.	6.00
12.	Direct geochemical & geophysical methods for evaluation of petroleum resources of moderately & poorly explored sedimentary basins of India.	12.00
	Total A_1	142.20
	A_2 : Production, reservoir studies & transportation	
$S_2G_2A_2P_1$	Small scale industrial projects for the utilisation of natural gas as feed stock	10.50
2.	Import substitution of critical items of oil field equipment	16.00
3.	Demulsification effluent disposal and allied problems	6.00
4.	Sand control in oil and or gas wells	6.00
5.	Well stimulation	9.00
6.	Modern secondary recovery methods	9.00
7.	Mathematical modelling	7.50
8.	Use of radio-active tracers in solution of production and reservoir problems	9.00
9.	Corrosion of pipeline, oil field equipment and its prevention	14.00
10.	Design and development of artificial lift equipment for oil fields	10.00
11.	Hydrate problems in high pressure gas transmission system	11.00
12.	Rheology of waxy and highly viscous crudes	11.00
13.	Exploration of deep-seated coal located in oil-bearing areas by insitu combustion	23.00
	Total A_2	142.00

1	2	3
	A_3 : **Biostratigraphy**	
$S_2G_2A_3P_1$	Age, environment, correlation and palaeogeographic reconstruction of the Vindhyan north of Narmada valley.	9.80
2.	Biostratigraphic zonation, correlation and palaeogeographic reconstruction of the marine sediments in the Gondwanas.	12.00
3.	Stratigraphy of the tertiary sediments of Tripura and its correlation with that of Bangla Desh.	15.00
4.	Meso-Cenozoic biostratigraphy of the south Shillong front. comparative study with that of Bangla Desh and Palaeogeographic reconstruction of the area.	7.50
5.	Palaeogene biostratigraphy of the Andaman/Nicobar islands and its inter-relationship with the Sumatran arc to the southeast.	5.00
6.	Neogene biostratigraphy of the Andaman/Nicobar Islands nd uits inteasr-relatiohip with the Sumatran arc to the southeast.	5.00
7.	Study and development of ancient coral reefs in the Cauvery basin	2.50
8.	Microfacies analysis and delta evolution	16.50
9.	Neopalynology of tropical areas and Mangroove swamps to understand and palaeoecology of tertiary and quarternary sediments.	12.00
10.	(i) Proparation and maintenance of Card catalogues *for* : Spores and pollen; Phytoplankton; Nanofossils; Forminifera; Ostracoda; and Radioloria (b) Maintenance of a type collection—a repository of type materia.	14.00
11.	Study of ecological and palaeoecological conditions of reef growth and development of mud banks during successive geological time (Kerala Coast).	10.00
12.	Micofacies studies and palaeogeographic reconstruction of the Subathu-Dharamsala group.	5.00
13.	Age, environment, correlation and palaeogeographic reconstruction of the vindhyan equivalent sediments in the peninsular region.	5.00
14.	Palaeontological and palynological studies of the Himalayan (Central) palaeozoics	5.00
15.	Palaeontological and palynological studies of the Himalayan (Central) mesozoic	5.00
16.	Age, environment, correlation and palaeogeographic reconstruction of infra krols, krols and tals.	5.00
17.	Comparative studies of the biofacies of the barails of geosynclinal areas and upper Assam.	15.00
18.	Palaeontological, palynological studies and palaeoecological interpretation of the Surmas and Tipams in the Surma valley and adjoining areas.	15.00
19.	Biofacies analysis and inter-relationship of transgressive/regressive phases in the coastal tertiaries of Kutch/Saurashtra and Kerala.	7.50
20.	Traces element and matrix study of the forminiferal test from the meso-cenozoic sequence of the Cauvery basin for determination of precise palaeoecological conditions for understanding of source rock development and various transgressive regressive phases-study based on Stereoscan.	4.50
21.	Stratigraphy and biofacies of the "Indus Flysch".	5.00
22.	Palaeotemperature analysis based on the measurements of the oxygen isotope ratio (O^{15}/O^{18}) from megafossil shells of mesozoic sequence of Kutch (Rajasthan) and Cauvery basins.	10.00
23.	Palaeomagnetic and biofacies study of neogene and quaternary sediments of Andaman-Nicobar Islands for precise determination of time planes and correlation of magnetic stratigraphy, biostratigraphy and faunal evolution.	4.50
24.	Age, environment, correlation and palaeogeographic reconstruction of the Simla States and other proterozoic-lower palaeozoic rocks of the extrapeninsular region.	5.00
25.	Study of foraminifera, ostracoda, palynofossils for the quaternary and recent environmental zonation and to demarcate plio-pleistocene boundary and to define neo-tectonic movements (raised beaches etc.)	7.50
26.	Evolution and development of operculate (classopollis group) pollen for delineation of time-stratigraphic boundaries in the mesozoic—palacogene sediments—study based on stareoscan.	3.50
27.	Microbiometric analysis of the rotalid group of foraminifera Cambay basin for detailed palaeoegeologic and timestratigraphic interpretation-study based on scanning electron microscope.	4.50
28.	Biofacies analysis of mesocenozoic sequence of Rajasthan and their correlation with that of Indus Basin.	3.40
	Total A_3	219.70

1	2	3
	A_4 : **Drilling Techniques and Processes**	
$S_2G_4A_4P_1$	Development of oil field trucks pipe layors etc.	3.00
2	Research programme to develop and manufacture of hard facing material for tool	1.50
3	Development of floating equipment and cementing collars	1.50
4	Development of core barrels	3.40
5	Development of Well heads Christmas tree and control gears	3.2
6	Development of B.O.P.	3.50
7	Development of kellys and drill collar	7.50
8	Development of handling tools	1.00
9	Development of casting manufacture	3.00
10	Indigenous manufacture of Rotary hose-Chicksen joints etc.	4.80
11	Development of fishing tools	6.00
12	Development of surface mud handling tools	1.60
13	Development of new type of rigs	41.00
14	Development and manufacture of drill bits	9.60
15	Development of drilling techinques for abnormal wells	9.60
16	Development of subsea completion techniques	1.60
17	Study of drilling economics	2.50
18	Development of directional drilling	6.00
19	Development of cementing techniques	12.50
20	Development of information system	2.90
21	Methods of forecasing high pressure and prevention of blow-outs	8.80
22	Research programme for pollution control	1.80
23	Training of personnel in well planning and material scheduling	5.00
24	Development and manufacture of recording and measuring instruments	1.00
25	Development of design and manufacture of rig equipment rotary swivel pumps, cementing pump.	5.00
25	Development of cassing and open hole packers	8.00
27	Micro bit studies	5.00
	Total A_4 :	153.60
	A_5 : **Sedimentary processes ard formation of Deltas**	
	Studies on Modern delta complexes	
$S_2G_5A_5P_1$	Mahisagar -Narmada-Tapti-deltas Complex	40.00
2	Godavari Krishna deltas Complex	40.00
3	Mahanadi Brahmani-Vaitarani deltas Complex	40.00
4	Barail group of Upper Assam	5.00
5	Tertiary sediments of South Cambay basin	5.00
6	Mesozoic-Tertiary sediments of Godavari-Krishna basin	5.00
	Total A_5 :	135.00

1	2	3
	A_6 : Drilling Mud and Oil Well Cement	
$S_2G_2A_5P_1$	Studies on problems connected with instability of mud systems at high temperature and development of thermo-stable additives/drilling fluids.	5.80
2	Studies on caving of shales and formulation of mud systems for the prevention of the same	4.80
3	Studies on damage of wells with poor permeability by drilling fluid and its remedial measures.	8.00
4	Preparation and maintenance of mud of high specific gravity (Sp. gr. of 2.0 and above) to balance high formation pressures.	3.30
5	Synthesis of mud chemicals and additives : (*a*) Metal lignosulphonate complexes, (*b*) Metal-lignite complexes, (*c*) Pregelatinised starch, (*d*) Polymers for low solids muds, for shale control, for water loss reductions etc., (*e*) Oleophilic bentonite for oil muds, and, (*f*) Others.	11.00
6	Formulation, completion and packer fluids	3.30
7	Studies on corrosion problems associated with the use of salt water workover fluids	3.50
8	Development of loss circulations materials	3.50
9	Development of invert emulsion muds using indigenous materials	4.60
10	Development of instruments for measuring : (*a*) Static filtration loss at high temperature and pressure, (*b*) Dynamic filtration at high temperature and pressure, (*c*) Rheological properties of mud at high temperature and pressure as well as normal temperature and pressure and under high shear rate. (*d*) Lubricating properties of drilling muds.	12.50
11	Manufacture of oil well cements	15.00
12	Studies on influence of flow characteristics of cement slurry on displacement of mud	6.00
13	Development of high polymers for squeeze jobs for repair work and water shut off etc.	8.00
14	Synthesis of chemicals for improvement of the properties of cement sluries e.g. fluid loss, viscosity, setting time and strength retrogression.	10.00
15	Studies on bond strength vis-a-vis expending characteristics of cement	4.00
16	Development of chemicals for solid removal from drilling mud to maintain desired weight and to increase drilling rate	4.80
17	Formulation of non-solid workover fluids	3.30
18	Mechanism of reaction between mud and mud additives e.g. thinners	4.30
19	Studies on carrying capacity of drilling fluids versusrheological properties and well hydraulics	5.00
20	Development of software for soloving mud problems	3.30
21	Design of artificial well bore for studies under simulated well conditions	4.50
22	Evaluation of materials for the preparation of low and high weight cement slurries	9.00
23	Development of instrument for measuring thickening time under high temperature and pressure	12.00
24	Development of software for cement slurry flow plan	4.50
25	Studies on strength retro-gression and its prevention	5.00
26	Fundamental studies on the preparation of different phases and studies on the effect of composition on performance characteristics	12.00
27	Studies on rheology and hydraulics of cement slurries	5.00
28	Studies of resilient cement	4.00
29	Recovery of barytes from left over/used up mud	4.50
	Total A_6	184.50

1	2	3
	Sub: Sub Sector A_7 : **Exploration Geophysics including Well-logging**	
${}_2G_2A_7P_1$	Design and development of digital seismic field system	30.00
2	Design of non-explosive seismic energy sources	7.00
3	Development of digital grade geophones	9.00
4	Development of modern well logging system	50.00
5	Data processing-software generation	38.00
6	Design and development of expendable and semi-expendable jet perforators	5.00
7	Development of proton precision and optically pumped magnetometer for air and sea borne surveys	3.00
8	Development of seismic field techniques, in folded areas	33.70
9	Delineation and identification of subtle traps for hydrocarbons (lithology) oriented interpretation of geophysical data).	4.00
10	Development of seismic field techniques in areas of high basement reliefs and number of of unconformities	24.00
11	Development of well log evaluation techniques for hetrogenous shally sands containing fresh water	8.40
12	Design and development of production logging equipment	27.90
13	Hardware for data processing	54.00
14	Documentation of geophysical literature in microfilms and computor based retrieval	22.00
15	Development of seismic field techniques in delta areas (including swamps)	77.00
16	Establishment of geophysical data bank and services	205.00
17	Mathematical modelling in exploration geophysics (including non-homogenous) non-isotropic and dissipative media).	9.00
18	Development of hydrophones for seismic work	7.00
19	Study of physical properties and evaluation of logging parameters on core samples under simulated formation conditions.	3.00
20	Development of instrumentation for side looking sonar and sparker sea bottom survey	11.00
21	Design and development of high density digital recording system	9.00
22	Studies of earth's crust and tectonics	37.00
23	Geophysical studies in Deccan trap areas	27.00
24	Development of magnetic-telluric instrumentation and techniques for geophysical studies	3.00
25	Data Processing—software for the future	10.00
26	Generation and application of shear waves in seismic exploration	5.00
	Total A_7	719.00

HIGHLIGHT OF IMPORTANT PROJECTS IN THE SUB-SECTOR OIL AND NATURAL GAS

Geochemistry of dispersed sedimentary organic matter of tertiary and pretertiary sequences of poorly explored sedimentary basins of India for evaluating petroleum generating conditions and petroleum source-quality (Punjab, Ganga, Rajasthan, Sanchor, Vindhyan, Godavari-Krishna, Palar, Andaman-Nicobar Basin and Gondwana Grabens).

Proposal is to make geochemical studies on the subject in order to identify and characterise source-beds of petroleum and to evaluate their distribution in space and time at the named locations. For carrying out these studies proposal is to collect various data on the organic matter distribution. Such data is helpful in facies analysis, paleo-environmental and paleogeographic interpretations of the rocks etc.

Basic expertise to conduct research in this area is available at ONGC. Various techniques available for petroleum source identification and potential evaluation are reported to have been tested and applied. Some sophisticated studies like isotope geochemistry, temperature programmed gas chromatography etc. have been proposed for solving the problem of origin, migration and accumulation of petroleum.

Study of relations between chemical composition of crude oils in the Cambay and Upper Assam basins with geology as clue to their origins

The present concepts on origin, migration and accumulation of petroleum have greatly emanated from the study of composition of petroleum and its relation with geology. The main objectives of this project are (i) to collect basic data on crude oil composition such as density, content and composition of dissolved light hydrocarbons, wax content, distribution of paraffinic, naphthenic and aromatic hydrocarbons, (mono, di, poly cyclic) in light and heavy fractions, content of asphaltenes and resins, content and distribution of hydrocarbon families in high boiling fractions and correlation indices etc., with a view to classify crude in a basin, (ii) collection of the data on large number of samples practically from every oil producing well with a view to apply statistical approach and computer technology for genetic correlation and to maximise chances of differentiating changes in crude composition due to insitualteration Vs. those caused by migration, (iii) to establish rational correlations with geology and to tackle problems of single source Vs multiple sources and shelf Vs. geosynclinal origin in Assam and fresh water Vs. marine origin in different parts of the Cambay basin. The solutions to the problems mentioned here will have important effect on exploration philosophy in India.

De-emulsification effluent disposal and allied problems

Oil exploration is associated with production of water which comes in the form of emulsion. Need is to intensify the RDD work for handling various types of emulsions and disposal of effluent produced along with emulsion while increasing the indigenous production of crude. The RDD work would also be helpful in producing various types of chemicals which are presently being imported. This would help in development of more industries and utilisation of manpower.

The proposed plan of work for this project involves the evaluation of the nature and properties of the oil field emulsions and effluent to be disposed of, the development of suitable chemicals/methods to break emulsions of various types, and finally the field trials of such indigenously developed chemicals.

Sand control in oil and/or gas wells

Very little work has been carried so far in this field and RDD to be expedited for controlling sand production problems. The work involves studies on the constitution and size distribution of sand grain in the oil wells and recommendations thereof for sand control. The work will help in optimisation of oil/gas production in our fields.

The plan of work is to review the literature and procurement of equipment, collection of core samples, sand grain studies, of consolidation material and finally the recommendations thereof.

Well stimulation

RDD work has been proposed in the field of well stimulation for those oil fields which cannot produce of their own unless stimulated by acidization and fracturing process etc. So far no work has been done in this regard in this country and need is to undertake this work for producing more oil.

The plan of work involves a thorough study of various producing formations of different oil fields in the country and development and evaluation of various techniques for well stimulation in the lab. and application of the same in the oil/gas fields.

Trace element and matrix study of the foraminiferal test from the Meso-Cenozoic sequence of the Cauvery basin for determination of precise palaeoecological conditions for understanding of source rock development and various transgressive/regressive phases—study based on Steroscan.

The above studies are important to precise determination of trace element and mineral species composition of different foraminiferal tests which will help in reconstruction of micro-environmental regimes and micro facies. This will lead to delineation of different phases of transgressions and regressions as well as the areas of better source facies development. All these are pre-requisite for programming exploration work and determining priorities in the Cauvery Basin. Better understanding of interrelationship of different transgressive/regressive phases will permit planning for exploration of stratigraphic traps. This project is of fundamental nature having applied aspect based on scanning electron microscopic and electron probe studies.

Palaeotemperature analysis based on the measurements of the oxygen isotope ratio ($0^{18}/0^{18}$) *from megafossil shells of Mesozoic sequence of Kutch (Rajasthan) and Cauvery Basins.*

Equilibrium reactions result in the separation of isotopic molecules. The equilibrium constant related to this separation is a function of the temperature at which the equilibrium is attained. The growth of marine shells takes place under these equilibrium conditions. The temperature coefficient of the equilibrium constant for equilibrium between oxygen and water and in carbonate is only 0.0176 per cent/C°. This, together with relatively small change of only 2.5 ppm parts of total oxygen leads to a predicted change in abundance of oxygen—18 for a 1°C temperature change. As a result of this rings on a shell grow.

Proposal is to measure the growth of rings on the shells of belemnites and other megafossils from mesozoic, surface samples from Kutch and Cauvery basin. This study will provide precise data on the temperature variation both in time and space, if any, between these two areas. These data will provide valuable information about the climatic conditions of the mesozoic time for a precise reconstruction of the palaeo-environmental pattern in time and space. The same data will also provide valuable information on stratigraphy and geological evolution as a whole. These data will be of great importance in our oil exploration programme.

Studies on Modern Delta Complexes

The delta studies are already in progress at ONGC where geomorphological and geophysical surveys in Mahanadi delta area have been undertaken. IIT Kharagpur has been conducting investigations on the basis of photo geomorphological, sedimentological analysis supported by an analysis of sub-surface data. Proposal is to extend these studies for better understanding of the process in delta formation.

In respect of the palaeo-delta studies only such projects which are likely to have an immediate bearing on exploration for petroleum have been given priority namely the Upper Assam Area, the South Cambay Basin and the Krishna-Godavari Basin.

The three priority programmes would involve studies on:—

(a) Godavari-Krishna Delta Complex

(b) Mahisagar-Narmada-Tapti Complex

(c) Mahanadi-Brahmani-Baitarani Delta Complex for search of petroleum etc.

Development of casing manufacturing (exploring the possibilities of manufacture of higher grade casings in smaller sizes and other grades in sizes larger than 7").

In India facilities are reported to be existing for manufacturing casings upto 7″ size in J-55 and N-80 grades of steel. Proposal is to manufacture higher grade casing in smaller sizes and other grades in size larger than 7″ because every year on an average more than one crore of rupees worth of such tublars are imported from abroad. These tublars like casings, drill pipes and drill collars are required as regular items of consumption in each oil or gas well drilled. The indigenous manufacture in collaboration with CMRI would help in stopping imports and saving F.E. It is envisaged that with the adoption of A.P.I. standards & producing tublar goods we can establish export potential of these goods to the neighbouring countries also besides meeting our own demands.

Development and manufacture of Drill bits

Drilling bits are perhaps the most important tool in the oil well drilling employed for cutting the formations. Nearly 2000 bits of different sizes and types are used every year by Oil and Natural Gas Commission alone, which cost nearly 50 lakhs of rupees in foreign exchange. Besides this a good number of bits must also be consumed by Oil India Ltd. Every day new bits are being developed to meet the changing needs of drilling oil wells. The cutting structure of the same type of bits is also being improved day by day. It will not be ideal to develop one type of bits which have been purchased or are available, but new type of bits with improved cutting structure have to be developed. For this project, it is therefore essential to have a research oriented approach for development on long term basis.

Development of high polymers for squeeze jobs for repair work and water shut off etc.

Squeeze jobs are done for repairing of cement failures. Development of high polymers for such squeeze jobs is absolutely necessary for successful remedy of sick-wells.

The polymers available for squeeze-jobs are covered by patents and hence no literature is available. Therefore, need has been felt to develop the know-how in India itself.

The proposed plan of work involves (i) study of high polymers for their chemical composition and their nature (ii) preparation of these additives on bench scale (iii) testing of these additives and their preparation on pilot plant scale (iv) recommendation about the techno-economics of developing these additives.

Synthesis of various mud chemicals and additives.

While drilling wells certain chemicals are added in order to improve the mud parameters for stability and an urgent need is felt in order to develop these chemicals indigenously. Co-operation between ONGC & CSIR labs. has been strongly recommended.

The proposed plan of work involves (i) detailed literature survey of different chemicals for proper maintenance of mud (ii) study involving analysis of different chemicals developed by foreign oil well companies and their indigenous synthesis (iii) setting up of pilot plant after the success of (i) & (ii) has been established. Sum of about Rs. 10 lacs has been asked for the setting up of a pilot plant laboratory which could further be expanded into a pilot plant.

Manufacture of oil well cement.

With the extensification of drilling activities, more and more cement will have to be imported because the indigenously manufactured cement by ACC cannot meet the demand for diverse types of cements. Need is to develop these diverse types of cement indigenously for diverse cementing conditions.

The proposed plan of work involves (i) development of oil well cements to suit different temperature and pressure and which could withstand some variations in temperature and pressure; (ii) choice of raw materials, experiments to prepare clinkers by varying the conditions of burning, cooling and grinding and testing physical parameters of final cemented conditions under simulated well conditions; and (iii) recommendation for chemical additives in cementing composition for regulating their properties as per well requirements.

It is envisaged that besides FE saving we may also earn FE by exporting these cements.

Design and development of digital seismic field system.

For retrieving and using all the information in a seismic signal the first requirement is that signals be recorded in digital form and in a format that is amenable for processing. Various processes and interpretative aids are possible only in case the seismic signals are recorded as faithfully as is possible.

Binary gain ranging systems or instantaneous floating point systems with digital recorders are being used more and more for this purpose in the seismic industry to achieve this objective. ONGC has already started using such systems.

As in future more such systems will be introduced in the country it will be worthwhile to make ourselves self-reliant in instrumentation.

Even though in the country no such work has been done so far but it should be possible to build a sound base for the project and achieve rapid progress with the experience available with ONGC.

Development of digital grade geophones.

The digital grade geophones are used in seismic exploration work in land with higher resolution and greater sensitivity than that obtainable from ordinary geophones of the same size. The slant will be towards miniaturisation without affecting sensitivity and also to make them very rugged for sustained use in field conditions without need of much care and without impairing the performance. These geophones are at present imported into India and are almost universally used for seismic work. The cost of digital grade geophones is about Rs. 200/- each and an average useful life of a geophone is about 7 years. Thousands of such geophones will be needed for seismic exploration work in the coming 10 years and about Rs. 2 lakhs will be required in foreign exchange to import these geophones only, besides replacement costs. With the development of these geophones indigenously all these expenses will be saved. Besides, it will also have indirect effect in the development of better quality magnets, toughened plastics and encouragement to improve material quality.

At present ordinary geophones are being partly made in India by importing the magnets and coils only. The rest of the components are being made in India and geophones assembled. Some permanent magnets are being made in India but they have yet to come up to the standard required for geophones. Also precision coil winding machines, which could wind coils with equal and matching impedances are needed to be developed.

Data processing-software generation.

In most of the geophysical methods of prospecting oil exploration, the information for more dependable interpretation is limited by the time required for the voluminous, tedious and repetitive calculations. Considering the time required for doing the calculations manually, geophysical industry has mostly switched over to computer data processing thus causing a considerable saving in time. ONGC has also started using digital computers for data processing. Software for several processes are available with ONGC but it is felt that all types of software required for data processing should be developed quickly so that the knowledge of sub-surface geology could be better utilised for more efficient oil exploration.

Delineation and identification of subtle traps for hydrocarbons (lithology oriented interpretation of geophysical data)

A good percentage of oil and gas production of the world is coming from stratigraphic/combination traps. Recent discovery of oil in combination traps in Kalol and southern plunge of North Kadi in Gujarat gives an impetus for carrying out an intensive exploration activity and meaningful extraction of information from seismic data in search of stratigraphic/combination traps in Gujarat and also in other basins of India.

With the advent of digital recording system and with powerful software programmes for data processing, reflection times and moveouts can be extracted more accurately for computing the interval velocities and, in conjunction with well long data, it can be translated into sand-shale ratio yielding useful subsurface information from the seismic data.

This project would also help in the development of new interpretation techniques, new applications of mathematical techniques in geophysical exploration and objective geological interpretation of geophysical data.

Design and development of production logging equipment.

Production logging services are indispensible for an efficient economic and optimum exploitation of hydrocarbon reserves.

Production logging services are employed after a well is completed to study the production characteristics. These services help to evaluate the behaviour of wells and reservoirs producing under stabilized conditions and serve to verify the status of the reservoir at a given time and also help update plans for optimum reserve depletion. Production services provide information about changes in production rates; flow/injection profiles; effectiveness of acidization or frac jobs; casing, tubing or packer leaks; entry of undesired fluids, theif zones etc; identification of entry point of fluids and their standing level depths; productivity index; production profiles; correlation of active zones; performance of pressure maintenance, gas storage, gas cycling and steam flood projects etc.

Some of the production services are available to the Oil & Natural Gas Commission and Oil India Limited through the contract services of a foreign firm. No integrated services is available in the country at the moment. None of the equipments constituting the service have been fabricated in India.

It is reported that the facilities exist in the country for the design and development of perforation equipment which constitutes a part of production services.

The items proposed to be designed are lubricator; flowmeter; borehole fluid density meter, differential thermometer; through tubing gamma-ray, neutron-gamma, C.C.L. cum isotope injector; casing inspection tool and truck, hoist, panels and associated equipment. The cable will have to be imported.

Establishment of geophysical data bank and services.

This project has been identified with a view to collect the various data and results available in the geological, geophysical and production fields/areas, in a computer based system. The facilities needed for the project include a large sized interactive computer with other accessories for carrying out the work on all the RDD proposals of Oil & Natural Gas subsector (both on land and off-shore). The envisaged large size computer is proposed to be utilised for all those RDD schemes of Natural Resources Panel which have been submitted by the subsectors other than Oil and Natural Gas subsector. The facility would be available for all the projects to be taken up in and around Dehra Dun also.

SUBSECTOR : *GEODETIC AND TOPOGRAPHICAL SURVEYS*

Maps are the basic pre-requisite for all economic and developmental activities. An accurate survey is essential for systematic proper investigations and planning for any development project, whether it be for hydro-electric generation and transmission, irrigation, railways, roads, town planning and urban development, identification and for making inventory of natural resources including minerals, forests, soils etc. or for civil administration or military needs.

Geodetic and Topographic activities in the country are mostly confined to the Survey of India, which has been carrying out its role for over 200 years in providing map coverage to the country in peace and war. But so far no systematic efforts have been made to organise research and development activity in the Survey of India. Neither personnel nor fund are specifically earmarked for this purpose. India has failed to keep pace with tremendous technological advances taking place elsewhere and as a result we are left far behind in the adoption of modern techniques in surveying & cartography. Only recently has there been some awakening in this respect. Modern techniques are necessary not merely to reduce the cost or to improve the quality of our products; more important is the need to produce the maps in time. Development activities cannot indefinitely wait for maps and they go ahead even on incomplete data resulting in considerable national loss. While it is impossible to assess directly the results of R&D in surveying, the economy effected by better planning and timely execution of our national development projects due to the availability of accurate maps in time will run into crores of rupees.

The increased tempo of developmental activity and the very rapid advancement in all branches of technology, particularly so in computer technology, automation and optics, have made it imperative that R&D activities be institutionalised properly as is the trend and practice in most of the advanced countries in the world and the latest technology used to produce appropriate maps and surveys.

In formulating the R & D Plans in this important area of natural resources the concerned Planning Group identified the vital areas in which national efforts in R & D are needed. As such the Group constituted seven sub-committees covering the following important areas of Geodetic and Tropical Surveys.

(i) Aerial photo-interpretation,
(ii) Cabastral surveys,
(iii) Geodesy,
(iv) Photogrammetry,
(v) Printing technology,
(vi) Survey and cartography,
(vii) Urban land-use and engineering surveys.

The above sub-committees took note of the fact that as more and more automation is introduced in the process of map-making, the speed of work and output will increase necessitating employment of greater number of people in different trades to keep pace with this trend. A further review was also carried out to select and earmark certain projects which could be given higher priority and which could be taken up immediately formulating the hard core of the proposals.

R & D proposals recommended by these groups are shown later. As an operative part it has been recommended that the proposed R&D activities should be carried out in existing R & D organisations and it is suggested that the existing institutes may be strengthened to take up the work load. It has been proposed that the following institutes be raised as separate entities under the Survey of India.

(a) Institute for Applied Cartography, including Integrated Surveys (The Indian Photo Interpretation Institute (IPI) at Dehra Dun would form the basis for this organisation).

(b) National Institute for Surveying and Mapping (The Survey Training Institute (STI) in the Centre for Survey Training & Map Production (C.S.T. & M.P.) at Hyderabad would form the basis for this organisation.

Research facilities in the IPI at Dehradun, C.S.T. & M.P. at Hyderabad and G & R.B. at Dehradun as well as R&D cells in Directorate of the Survey of India should also be created. In this context, it is worthwhile to mention the pioneering role of Roorkee University in developing photogrammetric education. It is recommended that the facilities at this centre should also be suitably augmented and encouraged.

Remote sensing for natural resources, standardisation and modernisation of cadastral surveys in states for land reforms, development of suitable classification systems for land-use, forestry and watershed management, R&D in instrumentation for survey and cartography work, integrated data bank, are among the more prominent R & D programmes proposed in this area. These are in addition to projects which will help in a faster survey and map production activity.

The group has identified a total of 45 projects in different areas of Topographical and Geodetic surveys. Of these, the following 2 projects relating to storage of information have been transferred to the National Information System for Science & Technology (NISSAT).

Project Index No.	Title of the project	Financial Outlay (Rs. in lakhs)
$S_2G_3A_1P_8$	Development of a Library of Natural Resources & Thematic Data as a Pilot Project.	8.00
$S_2G_3A_6P_4$	Integrated Data Bank.	36.00
	TOTAL	44.00

Table 1 below shows the distribution of the remaining 43 projects area-wise including the financial outlay involved.

TABLE 1

Break up of projects areawise

Area	No. of Projects	Total Financial Outlay (Rs. in crores)
1. Aerial Photointerpretation	8	3.990
2. Cadastral surveys	1	0.800
3. Geodesy	10	4.710
4. Photogrammetry	6	1.950
5. Printing technology	4	0.480
6. Surveying & cartography	6	1.050
7. Urban, land use and engineering surveys	8	1.385
TOTAL	43	14.365

The projects identified by the Sub Committe are given below

Project Index No. $S_iG_jP_k$	Title of project	Financial Outlay (Rs. in lakhs)
1	2	3
	A_1 : Aerial Photointerpretation	
$S_2G_3A_1P_1$	Soil & land use studies	14.00
2	Applications of remote sensing in forestry and watershed management	55.00
3	Geological, geomorphological, geohydrological and geoengineering studies by photo-interpretation & remote sensing	75.00
4	Evaluation of Cartographic potential of remote sensors and platforms for line maps and thematic maps.	80.00
5	Integrated surveys for development planning, using remote sensing techniques	30.00
6	Glaciological and glaciogeological studies in Himalayas	40.00
7	Aerial photo-interpretation and remote sensing in hydrology and flood control planning	5.00
8	Design and development of sensors, platforms and interpretation equipment suited for natural resources studies and evaluation of their interpretation capabilities.	100.00
	TOTAL A1	399.00
	A_2 : Cadastral Survey	
$S_2G_3A_2P_1$	Standardisation and modernisation of Cadastral surveys in India.	80
	TOTAL A2	80.00
	A_3 : GEODESY	
$S_2G_3A_3P_1$	Crustral movements in Himalyan region	60.00
2	Geodetic investigation for fault thrust studies	100.00
3	Gravimetric and geoidal framework for India	75.00
4	Study of earth tides	20.00
5	Determination of absolute orientation of Indian triangulation system	70.00
6	Application of satellite geodesy in India	35.00
7	Reality of changes of level in the Ganga delta region and other coastal areas	10.00
8	Provision of time and frequence service in the country	60.00
9	Adjustment of the new level net in India	21.00
10	Strengthening of the precision instrument repair workshop of geodetic and research branch	20.00
	TOTAL A_3	471.00
	A_4 : PHOTOGRAMMETRY	
$S_2G_3A_4P_1$	Development in navigational facilities of photographic flights, camera calibration techniques, image motion studies, image quality evaluation	50.00
2	Development and production of proto-type photogrammetric instruments	30.00
3	Research in techniques of extension of control by photogrammetric-methods.	20.00
4	Research in non-topographic photogrammetry	25.00
5	Research in map-photomap production & quality control.	20.00
6	Development in automation as applied to photogrammetry	50.00
	TOTAL A_4	195.00

1	2	3
	A_5 : PRINTING TECHNOLOGY	
$S_2G_3A_5P_1$	Development of photo-mechanical techniques for relief shading, photomap reproduction	10.00
2	Pilot project on production planning, control and systems engineering . . .	4.00
3	Development and introduction of quality control techniques	10.00
4	(i) Revision of specification for maps, to fit into standard size of paper . . .	3.00
	(ii) To introduce substitute for imported materials and standardisation of chemicals, films, etc. used in printing	18.00
	(iii) Research on plate making and colour proofing	3.00
	TOTAL A_5 .	48.00
	A_6 : SURVEYING AND CARTOGRAPHY	
$S_2G_3A_6P_1$	Development of Survey management techniques	5.00
2	Development of instruments and systems for measurement of distances and heights .	10.00
3	Map user evaluation study, map designing and relief shading	10.00
4	Development of an automated cartography system for generation of all types and scales of maps.	50.00
5	Development of computational techniques using electronic computers	15.00
6	Development of special survey equipment required for surveying and cartogrphic activities	15.00
	TOTAL A_6	105.00
	A_7 : URBAN, LAND - USE AND ENGINEERING SURVEYS	
$S_2G_3A_7P_1$	Development of suitable land use classification system and mapping	100.00
2	Changing pattern of land use in multi-purpose project area—Chambal valley project. .	10.00
3	Land utilisation in the northern and north-eastern mountainous areas of India . .	2.50
4	Changing pattern of land utilisation in Rajasthan, Gujrat and Eastern U.P. . .	5.00
5	Development of suitable urban land use classification systems with case studies of **Delhi, Calcutta, Bombay, Kanpur and Hyderabad.**	3.50
6	Pattern of natural resources utilisation in metropolitan regions and determination of range of residential density.	5.00
7	Land use planning of Aligarh, Etah, Manipur, Agra, Mathura, districts of U.P. . .	2.50
8	Inventory and mapping of engineering resources and classification of terrain. . .	10.00
	TOTAL A_7 .	138.50

HIGHLIGHTS OF IMPORTANT PROJECTS IN THE SUB-SECTOR GEODETIC AND TOPOGRAPHICAL SURVEYS

Soil and land use studies by Remote Sensing Techniques

Land and soil resources inventory is an essential pre-requisite for all planning and execution of agricultural development programme. Interpretation of aerial photographs are the quick means of surveying our soil condition and preparing of soil maps depicting the distribution of differently classified soils in a given region and incorporating thereon the soil characteristics that have significance to crop production. Presently the Indian Photo-Interpretation Institute, Dehradun has developed expertise in interpreting black and white aerial photographs. Since other remote sensing techniques including satellite imageries are now available elsewhere, this institute should undertake the study of (a) relative merits of black and white, colour and infrared photographs, (b) soil salinity and (c) crop identification and estimation of crop vigour, with a view to prepare a land and soil resource inventory for the whole of the country. The All India Land and Soil Survey Unit of IARI will also have to be involved for a more effective implementation of these projects.

Application of remote sensing in forestry and watershed management

Technologies are already developed in the developed countries like U.S.A., U.S.S.R., Canada, East-West Germany in the interpretation of aerial photographs, colour and false colour photographs, multiband and multispectral imageries and space and satellite photographs for forestry work. The information extracted from these sensors are being regularly utilised for forest mapping, forest topology, wild life management, watershed management and effect of forest on air pollution and flood control etc. On the basis of this interpretation forest inventories are being made. It has been accepted that the availability of satellite photography is opening up new vistas for preparing inventory over large areas simultaneously and in the shortest possible time. Technique of micro-densitometer and discrimination analysis is being utilised for identification of land use class and forest types. The Indian Photo-interpretation Institute at Dehradun has been so long utilising black and white aerial photographs for forestry work. It is hoped that earth resource territorial satellite photographs will be available for utilising in work connected with natural resource survey. Since, the Indian Photo-interpretation Institute at Dehradun has a nucleus for interpreting aerial photographs, it has been suggested that this institute should attempt to utilise these photographs for forestry application. The basic research should however be carried out through existing physical laboratories and universities.

The data will be utilised for planning of wood based industries and proper land use. This will expedite preparation of national forest inventory which will be useful to geographers, geomorphologists and earth scientists in describing and evaluating the vegetation and land forms of the country.

Geological, Geomorphological, Geohydrological and Geo-Engineering studies by Photo-interpretation and Remote Sensing

With the availability of latest techniques of aerial photo-interpretation and remote sensing echniques, it will be possible to arrive at a better, more accurate. economical and speedy ppraisal of natural resources, like, groundwater, minerals and thermal energy etc. The reearch aspect based on infrared, colour and geochemical studies of the mineralised belts will enable to have a better idea of the genesis and enrichment process of these mineralized belts. This will be helpful not only to have a better idea for the exploitation of these minerals but also for location or looking for other mineral occurrences. The study of the sand pattern in Rajasthan will help in elucidating the cases of the arid conditions and to determine the possible advance of the desert which will help in devising means to check this process. The geo-engineering studies will help in arriving at the most suitable alignment for the Ganga-Cauvery link Project and also checking the coastal erosion. The Geomorphological studies will help in having a better understanding of the causes of the periodic flooding, the extent of the floods and also the amount of excess water that would be available and could be utilized.

Glaciological and Glaciogeological studies in Himalayas

The increasing demand for water for industrial and domestic consumption and for irrigation and recreational purposes has caused water shortages in many parts of the country. On the other hand seasonal flooding of our main rivers causing dislocation in communication and agricultural work is a regular phenomenon. All our main rivers emanating from the Himalayas are glacier fed and a number of river valley schemes are coming up on these rivers. Hence a study of the behaviour of these glaciers assumes great importance. To stimulate study on the role of ice in the hydrological cycle the International Hydrological Decade programme established the world inventory of perennial ice and snow masses on and beneath the land surface.

Glaciology studies in temperate zones have advanced at a rapid pace and India, though a tropical country, has a large number of glaciers and therefore has a special role to play in similar studies. Geological Survey of India in association with Survey of India has since carried out surveys of some of the easily accessible glaciers, spaced at rather long intervals. With the recent technological development in the country in the field of photo-interpretation and remote sensing, it is now possible to carry out the surveys of selected glaciers systematically and expeditiously. The study should involve determination and mapping of the aerial extent of the glaciers, thickness, density and temperature of snow, measurement of water-equivalent of ice and evaporation from ice surface of the glaciers, melting characters of glaciers and their contribution to run-off seasonally.

Design and development of sensors, platforms and interpretation equipment suited for natural resources studies.

Indian Photo-Interpretation Institute has gained considerable experience in the interpretation of black and white aerial photographs for works relations to geology, soil survey, forestry, hydrology, cartography, engineering etc. With the availability of latest technology of surveying natural resources by remote sensors and multi-spectral photography, there is a need to design and develop sensors, like, infrared thermal scanners, panchromatic, color and false color photography by aircraft, multi-spectral cameras, side looking radar etc. These sensors will have immense application for undertaking studies in the field of forestry, soil survey and soil conservation, geology, geomorphology, ground water, hydrology, cartography and thematic mapping etc. The two important aspects of developing these sensors are :

(a) Data acquisition through sensors mounted on various types of platforms.

(b) Utilisation of these data for natural resource surveys.

The data should then be compared with those received from ERTS satellite, skylab under the project of NASA.

Standardisation and Modernisation of Cadastral Surveys

Accurate maps and graphic data of our land will provide the basic and accurate information to our planners for preparing the development plans. Presently, the states themselves are responsible for their own cadastral and revenue surveys, and they mostly depend on the age-ol method of surveying which is far from accurate. Recent development in photogrammetric methods of surveying has revolutionised the whole system of cadastral surveys. With the advent of the new land reform policy in the country an integrated approach is essentially required to standardise and modernise our cadastral surveys.

Besides utilising photogrammetry for cadastral surveys other experiments are also in hand for trying the use of rectified photo and orthophoto for such surveys. Under the project it is envisaged to undertake R&D work on the use of photogrammetry including rectified prints and orthophoto to the Cadastral Surveys which includes besides others, the urban mapping on large scales. Since the proposal is concerned with all the states of India, relevant data will be collected from the states and analysed and then the technical needs of the states will be identified. Necessary training of the officers of the states in cadastral surveys will be arranged.

Geodetic investigation for fault thrust studies

A number of river valley schemes are now in planning or construction stages in the Yamuna and the Upper Bhagirathi valleys. In view of the large concentration of earthquake epicentres in these regions which are attributed to recent tectonic history of the Siwalik block and the Himalayan belt, a systematic seismological study with reference to the various faults and thrusts present in the regions, has assumed considerable significance for the safe and economical execution of these schemes. The Koyna fault near Western Ghat has also assumed similar importance due to the severe earthquakes of 1967 in the Koyna dam area. Systematic geodetic observations are therefore necessary for a quantitative determination of any possible horizontal and vertical movements of these faults and thrusts, which will ultimately throw much light on the seismic state of the areas affected, and as such, will be of immense help to the project authorities in taking necessary precautionary measures for carrying out their schemes more safely and economically.

The Geodetic and Research Branch of the Survey of India is engaged in observations with triangulation and levelling observations across many fault schemes. In order to find any change in the position of these faults, observations are required to be repeated at shorter intervals. The measuring system would consist of frequent observations of selected distances by geodimeter or mekometer and reobservations of levelling lines every three or four years connecting some stable stations/bench-marks at coastal areas. For this purpose, it is envisaged that tide gauges, tilt-meters and laser gauges will be in continuous operation in these areas.

Determination of Absolute Orientation of Indian Triangulation system

Accurate information on the orientation of our triangulation system is the essential input to all sciences like Geophysics, Geology, Hydrology and Seismology with special emphasis on their application to the survey and exploration of our natural resources. For determining the orientation of triangulation there is need to acquire a complete knowledge of the distribution of the earth's gravity anomalies accurate in the neighbourhood of the computation point and in broad lines over the rest of the country. The Survey of India has a chain of network of gravity stations in some areas for which gravimetric deflection of the vertical have been computed. There are, however, many wide gaps yet to be filled up along the difficult range of the Himalayan region and portions of the Arabian Sea and the Bay of Bengal. The method of computation employed for determining the gravimetric deflection was based on the old concept of Indian Everest Spheroid of reference and this will have to be revised fitting into the standard earth system adopted as the International Reference Spheroid, 1967. Apart from these repeated measurements of the Geodetic Satellite Stations near Dehradun, Nainital and Trivandrum including the one at Kalianpur, may also throw light on the quantitative idea of any possible drift or relative tectonic movements between the old peninsular shield and the Himalayas block. For this purpose geodetic instruments would be installed at these satellite stations. The two sets of absolute values of the deflections of the vertical at the initial stations of the triangulation system will be compared by both gravimetric and satellite geodesy methods. For the precise determination of the spheroid-geoidal separations, the existing geoidal circuits will be carried out upto the satellite stations for the precise computation of their vertical deflections.

Application of Satellite Geodesy in India

Satellite geodetic studies have already been undertaken and are actively being pursued in several western and eastern countries of the world but have not yet been started in India. The major practical and scientific benefits that will accrue by introducing satellite geodesy are:—

(a) Provision of control points for readjustment of our triangulation system.

(b) Provision of geodetic connection to outlying islands of the country.

(c) Study of plate-tectonics.

(d) Comparing gravity anomalies with those derived from ground gravity observations.

The programme is based on the proposed observations to the existing foreign geodetic satellities that are already in orbit and are suitable for our observation programme. In order to use these satellites the cooperation of foreign-international agencies would be essential for getting satellite orbital parameters, look-angles and satellite prediction.

Research in Techniques of Extension of control by Photogrammetic Methods

Accuracy in surveying and mapping work is dependent upon availability of good and sufficient controls. Research in the field of extension of control by photogrammetic methods will result in considerable economics in the production of maps and would also speed up the process of map making. Development of techniques of extension of control by analytical methods would also enable use of such techniques in other allied disciplines like cadastral surveys and engineering surveys. The technique once developed can result in preparing maps of even un-chartered areas with limited and sparse control. Proper understanding in this field and use of correct instruments and computer facilities would be required. The Centre for Survey Training and Map Production under the Survey of India is now running an advanced course in photogrammetry. Amongst the universities only Roorkee University has taken a pioneering step in starting a photogrammetic course. The technique so developed will by extremely useful in improving the efficiency and map production capacity of the Survey of India.

Researches in Non-Topographic Photogrammetry

The technique of photogrammetry can be applied not only for map making, but in very many development activities such as:—

(i) Cadastral mapping.

(ii) Engineering problems.

(iii) Military science.

(iv) Underwater applications.

(v) Topographic, geological and soil mapping.

(vi) Structural engineering, ballistics, fluid mechanics, medicine, archaeology, architecture, etc.

The existing Indian Photo-Interpretation Institute has developed techniques of photo-interpretation but their emphasis is more on the qualitative aspect of photo-interpretation rather than on quantitative aspects and accordingly the latter sphere has got to be developed.

Development of an Automated Cartography System for Generation of all Types and scales of Maps

Incorporation of various information on base maps by normal methods, is time consuming and the resulting maps are available for planners only after a long lapse of time. Map drawing can be speeded up by factors by the introduction of automatic cartography. Other parameters can be overlaid on best maps on different scales. The flexibility of automatic cartography, in which a change of scale can be obtained by pressing a button, is very significant. Alternatively, a complex map containing many economic variables can be taken to pieces and the map can be presented with a single variable or in different combinations of these. As such methods and systems developed will be of immense value to other agencies, who possess data in numerical forms such as census data, agricultural statistics, commercial statistics, industrial statistics etc. Under the Scheme it has been envisaged that all information contained in a map which has a large number of special symbols, colours, words, and numbers will be converted into binary digits such as 0 and 1 for feeding into an electronic computer. The information will then be edited and compressed to enable easier processing and compatibility with other information and mapping information. A suitable plotter control system will be utilised to draw the symbol, lines and words on an accurate plotting table. This will have a predominant utility in census and other departments concerned with commercial, agricultural statistics in both centre and state sector, National Atlas Organisation, Geological Survey of India, Oil and Natural Gas Commission.

Development of suitable Landuse Classification System and Mapping

The landuse and its survey is so complex in nature and its contributors and user organisations are so varied that an integrated and comprehensive project need be evolved to make the work all purposeful. No organisation at present is doing these surveys on an organised basis, which is an urgent need. The data will cater to the immediate needs for establishment of a national level system, equipped with experts of various fields forming an integrated team, to produce such maps on a continuing basis over a ten year cycle, on variety of scales for national, regional and local/project levels (macro, meso, micro/microscopic levels) beginning with some pilot project areas. For this purpose efforts will be made to develop aerial photo-interpretation and remote sensing techniques as photographs and integrated data in all the relevant disciplines. This would form an integrated regional landuse and resource map for planners at various levels so that they can orient their detailed planning based on this data and fit them into the overall national framework. With a view to evolve a suitable methodology and to serve realistically the immediate requirements of some priority project areas as the input product, the group has identified three different types of areas with different functional requirements. These areas will be (a) South East resource region, (b) Ganga-Cauvery link canal regional, and (c) Under developed areas *e.g.* Northern hill districts of India. A team of experts from the Town and Country Planning Organisation, Survey of India and other agencies will conduct surveys in selected areas of this region and prepare a preliminary report in two years and final report in five or seven years. A second team of experts from Central Water and Power Commission, Survey of India and other Institutions would carry out the studies in selected areas of Ganga-Cauvery link canal region according to the priorities of the Central Water and Power Commission. The third team comprising of experts from the local regions including universities and other planning organisations could undertake study in four specific regions of the under-developed north and hill areas. It is expected that a preliminary land use classification will emerge on regional basis within the next two to five years. A national classification system will subsequently emerge within about 7—10 years. .

Changing Pattern of Landuse in multi-purpose Project Area—Chambal Valley Project.

On the basis of interpretation of available aerial photographs, it is possible to compare and contrast the trends of changes in a locality over a certain period of time *e.g.* 15 years. Such photographs over such an interval are available with the Chambal Valley Corporation and with Survey of India. The study will be useful in developing a methodology in assessing the socio-economic, technological, physical, natural and ecological factors contributing to such a change in the land utilisation. Since requisite data for the Chambal valley project area are available, it will be worth-while to undertake the project as vally project studies which may have a national utility for similar multi-purpose river valley projects. But it has been envisaged that aerial photographs, to begin with, will be interpreted for two different intervening years which will be followed by an extensive and intensive field checking for the existing conditions. Maps will be produced for the periods which can be evaluated to indicate not only the changing pattern but also the intensity and variations of such change based on various landuse categories. The analysis will provide not only the regional personality and model of landuse utilisation pattern and its trend but it will also help in formulating future policies and its directions for planning purposes.

Sub-sector : MINERAL RESOURCES

Minerals are among irreplaceable forms of natural resources. Plants and animals may be bred in successive generations, depleted soils may be restored to fertility, and barren wastes may be afforested to productive maturity, but a mineral deposit that has been truly exhausted is beyond restoration and this fact is of the utmost importance in any consideration of the problems of conservation associated with the utilisation of mineral deposits. Mineral conservation can be defined as intelligent utilisation of mineral resources with a proper regard for the rights of future generations. The wisdom with which the minerals are employed will control the economic future of the contry.

Hence the proposed programme of work in this should have a bearing on our immediate requirements of minerals, both with regard to surveys and R&D programmes. The main problem will be to utilise low grade ores and medium sized deposits. Also suitable alternatives for those resources which are scarce in this country should be found. Greater stress is necessary on the minerals which are strategic for our industry, some of which, like sulphur, asbestos, fertilizer minerals, and graphite are being imported presently.

Remote sensing programmes comprising aerial geophysical surveys, scintillometric studies, infrared and multi-spectral scanning and satellite surveys should be employed for a vast coverage of surface and for detection of pests and diseases in plants. These aerial surveys will also play a vital role in quick location of potential mineralised belts. The necessary facilities and know-how already existing in the NGRI, Atomic Minerals Division, etc., should be made full use of, by the country, instead of employing foreign agencies to do these jobs.

India's continued dependence on imports for a number of minerals needed to sustain our industry is attributable mainly to the gaps existing between exploration and exploitation. The gaps can be traced to a number of causes for which no single organisation can be made responsible. The exploitation programmes are more expensive and involve a greater technical know-how. While the needs of an exploiting agency are sometimes not properly visualised by the exploring agency, such gaps could be overcome by associating the exploiting agency after a certain stage in the evaluation of a prospect. Other problems that arise in this area are mainly those relating to drilling, mining and metallurgical aspects. There is also a great need to have a Central Designs Institute for mineral industries mainly in the ferrous, non-ferrous and coal sector to deal with the peculiar problems arising in these areas.

Research in Economic Geology is mainly fundamental in nature, but has important applications in areas such as genetic aspects of ore, evolving regional patterns and evaluation and development of mineral deposits. Research on ores by studying the polished sections, geochronology on mineralised zones, genesis oriented studies on placer deposits, environmental studies in relation to the ore deposites, trace element studies etc., are very helpful in this area.

It is well known that igneous activity, tectonism and mineralization are closely related. A proper structural analysis of the area of investigation is a pre-requisite for planning the mineral exploration work. India has very complex geological history and much of its area is of the Pre-Cambrian sheild. We have still vast areas like Satpura belt, Delhi belt, Aravali belt, Sone Narmada trough, the Western and Eastern ghats and Dharwar belt, which need both regional and detailed investigations.

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Geochemistry and petrology are some of the main fields in which very little work is being done in this country. The trace element studies give a precise estimation of various elements in a given ore and the entire country should be covered by regional geochemical studies on rocks, soils, and stream sediments. Water and plants will provide us many clues regarding the occurrence of mineral deposits. In other countries like USSR such work has been of great value, resulting in rich dividends. It is high time that we intensify our work in this direction.

The need for an inventory of natural resources and a data bank wherein all types of data geological, geophysical and geochemical could be stored has been a long-felt need. A centralised agency with computer facility for data processing to help storage and retrieval of data should be established forthwith. Operational research studies are also necessary in exploration, planning and management on mineral exploitation programmes, since it is only these studies that give an idea of various parameters involved leading to optimisation of costs. Computer applications in exploration, geophysics, mineralogy, petrology, palaeo-ecology, mining geology, and various other branches of earth sciences are increasing everyday and a centralised data processing centre for earth sciences is imminent.

The 13 sub-committees set up in the sub-sector contained representatives from all major organisations like GSI, AMD, NMDC, NCDC, Coal Board, IBM, NGRI, SOI, CFRI, PRL, BARC, Planning Commission, Universities/IIT's, State Departments of Geology/Mining Corporations. The total number of projects proposed are 137 with an outlay of about Rs. 36.5 crores over the Fifth Plan period, as detailed below:—

S. No.	Sub-Committee	No. of Projects	Financial Outlay (Rs. in lakhs)
1	2	3	4
1.	Atomic minerals	13	285.00
2.	Ferrous minerals	12	349.75
3.	Non-ferrous minerals	10	593.30
4.	Industrial minerals	8	16.25
5.	Coal and lignite	13	285.60
6.	Geophysical exploration	15	246.00
7.	Remote Sensing	6	285.00
8.	Gaps between exploration and exploitation	3	550.00
9.	Economic geology	9	52.50
10.	Structure and tectonics of mineralised belts	6	20.00
11.	Geochemistry and petrology	16	571.10
12.	Data processing	16	351.25
13.	Frontiers of earth sciences	10	42.15
	Total:—	137	3647.90

A. Projects worth Rs. 724.40 lakhs were transferred to the Panel on Mining, Steel and Metallurgy.

B. NCST was of the view that some of the projects could be undertaken in the routine work of the Department and they do not require extra outlay. They are as follows:—

Project Index No. $S_iG_kP_k$	Title of Project	Financial Outlay (Rs. in lakhs)
1	2	3
$S_2G_4A_3P_5$	Detailed petrological, structural and chemical studies for determining the sources and method of emplacement of gold bearing lodes (GSI)	0.70
$S_2G_4A_3P_9$	Pilot plant studies for benefication of low grade bauxite (IBM)	40.00
$S_2G_4A_6P_3$	Field investigations for research items (GSI).	55.50
$S_2G_4A_6P_{10}$	Experimental research projects (GSI)	10.00
$S_2G_4A_6P_{15}$	Mathemetical research projects (GSI)	2.50
	TOTAL:—	108.70

C. A national information system for Science and Technology (NISSAT) has been identified as an area of very high priority.

From the Mineral sector the following project has been transferred to the NISSAT:—

Project Index No. $S_iG_kP_k$	Title of project	Financial Outlay (Rs. in lakhs)
1	2	3
$S_2G_4A_{12}P_1$	Inventory and Data Bank Natural Resources.	150.00

Thus substracting the amounts from A, B, & C which comes out to be Rs. 983.10 lakhs the outlay in the Mineral Sub-Sector comes out to be Rs. 2664.80 lakhs. The projects identified by the sub-committee are given in the following pages.

A_1—Atomic Minerals

Project $S_iG_jP_k$*	Title of the Project	Financial Outlay (Rs. lakhs)
1	2	3
$S_2G_4A_1P_1$	Delineation of geochemical zones in mobile belts to identify zones favourable for mineralisation of atomic minerals.	35.0
2	Mapping of grantic plutons and other intrusions and zones of weakness favourable for both exo-and endogenous mineralisation.	17.00
3	Studies on petro-chemical characters of granites, apogranites, rhyolites and skarns. etc.. for locating significant resources of U, Cb-Ta and Be mineralisation.	52.0
4	Studies on the geochemistry of alkaline massifs (a) associated with mobile belts and (b) those associated with zones of crustal fracturing in cratonic blocks, rift structures deep faults and block faults, and their bearing on possible locales and nature of mineralisation.	9.0
5	Exploration geochemistry-preparation of regional geochemical maps as aid to selection of areas which indicate the presence of hidden deposits not only of uranium and other atomic minerals but also of other base-metal ores and the like	12.0
6	Research to evolve a quick and simple field analytical method for detection and quantitative or semi-quantitative estimation of columbium-tantalum.	3.0
7	Researches on development of methods whereby hidden uranium resources may be located by measuraement of radioactive elements, radium, radon, krypton-85, Xenon-133, and tritium, and non-radio-active isotopes of deuterium, oxygen, nitrogen, helium, and argon in natural waters.	3.0

1	2	3
8	Studies on fluid inclusions in minerals to decipher the composition, temperature and nature of hydro-thermal solutions to ascertain whether they could be used as guides to mineralisation.	11.0
9	Role of colloidal solutions in mineralisation.	10.0
10	Stable isotope geochemistry, with special reference to O, H, C, and S isotopic compositions and their bearing on temperatures, environments, sources and nature of fluids, in order to ascertain whether they could have led to mineralisation in any given area.	28.0
11	Research in radioactive isotope geochemistry in Indian environments to be used as an aid in mineral exploration.	19.0
12	Modelstudies for interpretation of results of geophysical surveys.	15.0
13	Proposals for research in problems of (i) slime flotation ; (ii) efficiency of flotation machines ; and (iii) grindability studies in the processing of ores.	27.00
	TOTAL A_1:	350.*

A_2 *Ferrous-Minerals*

$S_2G_4A_2p_1$	Techno-economic studies of ferrous minerals in different metamorphic terrains of South India.	2.15
2	Structural analyses of basins of Iron ores with special reference to selected iron ore and manganese ore deposits.	2.00
3	Metallogenesis in the Deccan Traps with special reference to Fe-Ti oxides and Fe-Cu sulphides.	1.00
4	Assessment of Manganese ore resources of India with reference to quality, nature of impurities, mineralogy, etc.	2.50
6	Magnetic surveys of Iron ore formations in Andhra Pradesh.	0.70
7	Investigations on the Iron ore deposits of Eastern Region.	2.50
8	Study of the ferrous metal ore deposits of Mysore State. (ores of Iron, Manganese and Chromium.)	2.50
9	Tungesten ore mineralisation of Ranibhandh-Khatra area of Bankura district.	1.00
10	Systematic investigation of Magnetite ore deposits in Southern Region, with reference to beneficiation, pelletisation and manufacture of special steels	250.00
11	Systematic investigation of all Manganese ore deposits of India.	50.00
12	Systematic investigation of all Chromite deposits of India and categorisation according to industrial requirements.	35.00
	TOTAL A_2 :	349.35

A_3-Non-Ferrous Minerals

$S_2G_4A_3p_1$	Systematic surface examination and sampling of ultramafic belts for the occurance of Platinum.	5.00
2	Beneficiation studies for determining suitable methods for recovery of Platinum.	5.00
3	Examination and evaluation of the assay plans for working gold mines.	0.60
4	Beneficiation studies for determining suitable methods of recovery of by-products like Tungsten and Arsenic from Gold ore.	2.00
5	Laboratory investigation of new methods of economic recovery of metals from low grade ore like bacterial and chemical leaching.	10.00
6	Pilot plant tests for recovery of metals like Germanimum, Vanadium, Titanium, etc., from red mud.	10.00
7	Systematic evaluation of all base metal occurances in the country.	500.00
	TOTAL A_3 :	532.60

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*This figure is for 2-7 yrs. For 5 yrs the amount is Rs. 285 lakhs

1	2	3
	A_4 = *Industrial Minerals*	
$S_2G_4A_4P_1$	Studies on the effective use of Graphite in Orissa.	2.50
2	Geophysical studies on Barytes Steatite and asbestos minerals in parts of Mahboob nagar district, Andhra Pradesh.	1.50
3	Location of new Diamond occurences in the Panna Belt by sedimentalogical studies.	1.50
4	Investigation of the industrial utilisation of clays from Andhra Pradesh.	1.00
5	Investigation of limestone and dolomite deposits of Chatisgarh Basin, Madhya Pradesh.	0.75
6	Investigation of Steatite and asbestos in Cuddapah and Anantpur districts, A.P.	1.50
7	Exploration for Magnesite, Potash, Sillimanite and Kyanite	5.00
8	Production of activated carbon and utilisation of low grade Graphite.	2.50
	Total A_4:	16.25
	A_5 = Coal and Lignite	
$S_2G_4A_5P_1$	Geological and petrological studies of coal and coal seams of Godavari valley in relation to their utilisation	3.00
2	Petrographic and coking characterstics of coal from Kanhan valley, M.P.	0.20
3	Gravity and magnetic surveys over Damodar valley coal fields.	0.65
4	Quantitative lithofacies analysis and sedimentation trends of coal bearing Barakar formation in the East Bokaro coal fields, Bihar.	0.20
5	(a) Study of the trend, lithology and dimentary structure in the Barakar formation of the Raniganj coal field.	0.50
	(b) Sedimentalogical study of the Karabari formation in the type area and other coal field basins.	0.30
6	Coal resource studies of the Raniganj coal fields.	0.75
7	(a) Petrographic studies of coal as a guide to selective preparation, beneficiation, carbonisation, solvent extraction and hydrogenation.	20.30
	(b) Geomicrobiology of fossil fuels.	2.70
8	Experimental studies on the fluvial process responsible for Gondwanas sedimentation.	4.00
9	(a) Compaction studies of agglomerates from a blend of blue dust.	3.50
	(b) Electrostatic precipitation of fly ash from coal burning.	0.50
10	(a) Utilisation of fly ash from power stations for stowing and other purposes.	5.00
	(b) Development of indigenous mechanical stokers and gas products suitable for Indian coals.	15.00
	(c) Undertaking feasibility and plant scale trials on Upper Assam Coals in coking blends.	2.50
	(d) Study of the corrosion/erosion problems in the use of low grade coal in PFF boilers.	7.00
11	(a) Palynological zonation of Karharbari and Barakar stages.	1.00
	(b) Petrology of Singrauli Coal Seams.	1.00
12	Stratigraphic, tectonic and sedimentalogical frame work of Peninsular Gondwana Basins with special reference on coal formations.	13.50
	Total A_5:	81.60

1	2	
	A_6=Geophysical Exploration	
$S_2G_4A_5P_1$	Integrated studies for regional assessment of the Arawalli Mineral belt.	40.00
2	Integrated Survey in the Bundelkhand and Singhbhum regions for assessment of mineral potential.	40.00
4	Regional gravity, magnetic and rediometric surveys over an intervening zone between Cuddapah and Pakhal basins.	2.50
5	Well logging studies on the quality estimation of ferrous and base metal deposits.	2.50
6	Magnetic study of the metamorphic complex of Dhanbad area.	1.50
7	Development of automobile gamma metohod and amanometric method of prospecting for possible radioactive minerals in parts of Mehbubnagar Distt. (A.P.)	2.50
8	Development of nuclear geophysical methods of analysis of ore and rock samples in the laboratories and in situ.	2.00
9	Technique for exploration of mineral resources.	80.00
11	Laboratory studies on the physical properties in rocks and minerals. . . .	1.50
12	Studies on the pressure and temperature dependence of the electrical properties of rocks	1·00
13	Electromagnetic models for airborne mineral survey.	2.0
14	Theoretical, model and field investigations on geophysical methods for prospecting. (surface & walls)	2.50
	Total A_6 :	178.00
	A_7—Remote Sensing	
$S_2G_4A_7P_1$	Aeromagnetic survey of the entire country with flightline interval of 5 Km. covering off-shore areas Andaman, micobar, Laccadive and Minicoy islands and Sikkim, Bhutan.	150.00
2	Establishment of a Central Flight Group and import of navigational and position location system	20.00
3	Geochemical sensors for carrying out airborne surveys	40.00
4	Development of television type sensor system	25.00
5	Improvement in existing systems, design construction of multispectral and microwave devices	25.00
6	Development of satellite based sensing systems	25.00
	Total A_7 : .	285.00
	A_8 Gaps between exploration and exploitation	
$S_2G_4A_8P_1$	Augmentation of mineralogical laboratory facilities of GSI.	50.00
	Total A_8 : . . .	50.00
	A_9—Economic Geology	
$S_2G_4A_9P_1$	Studies on precambrian Geology	20.00
2	Economic geology of oxide Mineral deposits	5.00
3	Physico chemical conditions of formation of rocks and minerals	2.50
4	Petrogenesis of granite and granitic rocks	2 50
5	Geochronology and sulphur isotope studies on mineralised zones	3.00
6	Genetic studies of the mineral stands along Kerala Coast	2.00
7	Hydrometallurgical recovery of copper from chalcopyright concentrate . . .	5.00
8	Environmental approach in the investigation of ore deposits of Mysore state . .	2.50
9	Technoeconomic studies on some selected mineralised zones of the country. . .	10.00
	Total A_9 : . .	52.50

1	2	3
	A_{10}—Structure & Tectonics of Mineralised Zones	
$S_2G_4A_{10}P_1$	Structure and stratigraphy of Iron group in the Jamda-Koira Valley. . . .	1.50
2	Revision of the Pre-cambrian stratigraphy and structure of southern and central Rajasthan.	3.00
3	Structural studies in and around the Gua, Iron ore Mines, Bihar.	0.75
4	Structural studies in the Pre-cambrian rocks of Krishna-Guntur-Khamman Distt. .	2.50
5	Regional tectonic and structural investigations in the Eastern Ghats.	7.25
6	Structural studies of the lesser Himalayan Carbonate Zone, Kumaon. . . .	5.00
	Total A_{10} : . .	20.00
	A_{11}—Geochemistry and Petrology	
$S_2G_4A_{11}P_1$	Regional geochemical survey to help in delineation of mineralised zones, location of haloes and preparation of geochemical maps.	400.00
2	Strengthening of laboratories in Petrology and Geochemistry for regional survey	150.00
3	Experimental studies on silicates sulphides and oxides and their bearing on problems of petrogenesis and ore genesis	2.50
4	Petrological and geochemical studies in the gold bearing and associated rocks of Hutti, Ramgiri and Bissanatam areas of South India.	2.50
5	Geochemical investigation on the charnockites and related rocks in Mysore State.	0.60
6	Petrological and Geochemical study of sediments of the Punjab Himalayas.	2.50
7	Regional Geochemical exploration Wainganga river valley.	2.50
8	Geochemistry and petrology of rocks containing sulphide mineralisation inparts of Medak, Nizamabad and Karimnagar Distts. A.P.	0.50
9	Tracele ements in rocks and associated exigencies materials in Nellore Distt.	2.50
10	Geochemical and Pertological studies in Indian Carbonatites and associated mineralisations.	1.00
11	Petrology and Geochemistry of petrozonic sediments of Chattisgarh basins in M.P. and their palaeogeggraphic and and Palaeogeophysical implications	0.75
12	Mineralisation connected with the Precambrian basic igneous activities in the areas around Gwalior, M.P.	0.25
13	Study of Indian anorthosites for locating metalliferrous deposits.	0.25
14	Geochemical investigations for possible source rocks for Cusulphides, Apatite-Magnetite and Barium minerals along S.E. Singhbhum.	0.75
15	Geochemical investigations of Petromineralogical and the metamorphites and associated rocks with special stress on mineralisation events.	2.50
16	Petrological studies of Eastern Ghats.	2.00
	Total A_{11}:	571.10
	A_{12}—Data Processing	
$S_2G_4A_{12}P_2$	Estt. of Geodata Centre for Minerals and Earth Sciences at GSI/IBM/MEC	150.00
3	Data Processing and optimum planning for Natural Resources Systems	10.00
4	Development of quantitative process response models for the genesis of granitic rocks and of associated mineral deposits in Singhbhum, Bihar, Mica belt and Purlia-Bankura regions	2.00
5	Operations research and geostatistical analysis of optimum planning and appraisal of mineral resource system.	2.50
6	Software development for mineral exploration studies	1.50
7	Processing of geophysical data at Centre of Exploration Geophysics	1.50
8	Computer applications in mineral exploration	4.00

!	2	3
	9 Analytical reduction of geophysical data and functional evaluation	0.50
	10 Geophysical data evaluation procedures	0.50
	11 Statistical analysis of Barakar stratigraphic sequences as a Markov process	0.50
	12 Quantitative studies related to economic importance of Gangpur Group of rocks of Orissa.	1.50
	13 Training of personnel in data processing in various fields of earth sciences	21.00
	14 Processing of coal mines data	2.00
	15 Processing of seismological data	2.25
	16 Processing of geomagnetic observatory data	1.50
	Total A_{12}	201.25
	A_{13}—Frontiers of Earth Sciences	
$S_2G_4A_{13}P_1$	Ore Genesis	2.15
	2 Thermo dynamic properties of important mineral groups	2.00
	3 Ocean bottom seismology	5.00
	4 Magnetic properties of rocks	2.00
	5 Evolution of folds and thrusts of regional scale in orogenic belts	2.50
	6 Prediction of earthquakes	2.50
	7 Marine magnetic studies of the Indian Offshore Region	10.00
	8 Integrated studies on the Deccan lava flows	10.00
	9 Interaction of E.M. waves with inhomogeneous media	3.00
	10 Globa synthesis of observed Physical and geological fields	3.00
	Total A_{13}	42.15

HIGHLIGHTS OF IMPORTANT PROJECTS IN THE SUB-SECTOR MINERAL RESOURCES

Delineation of geochemical zones in mobile belts

There are hardly any maps and sufficient literature available on geochemical zones for mobile belts in India. It is well-known that igneous intrusions, which are a source of primary mineralisation in rocks, differ from one another in the mio-geosynclinal and eugeosynclinal areas and impart to them specific geochemical characters, and thereby, favour formation of specific minerals in each of them. Results of research and mapping of such regions, particularly with details of the evolutionary history of these belts, would enable the geologist to direct his exploration effort for specific minerals to particular geochemical zones. Considerable work has been attempted in this direction in USSR, etc. Research to develop knowledge in this field in India has still to be undertaken on a scale commensurate with the problem.

Mapping of granitic plutons and other intrusions and zones of weakness favourable for both exo and endogenous mineralisation.

But for a few instance, mapping of granitic plutons and zones of magnatic differentiation in peninsular and the Himalayan terrains, to which mineralisation in certain areas may be ascribed, is yet to be carried out. Even where maps are available, they do not delineate different phases of granitic activity in these areas. The importance of this work as well as the delineation of any zone of weakness such as faulting, fracturing, and brecciation of host-rocks around the granitic intrusives, following or accompanying the intrusions, can hardly be over-emphasized as it would provide valuable information not only of the different types and periods of intrusive activity but also about the sites favouring mobilization of mineralising solutions with possible formations of deposits of economic importance.

Ferrous Group

The country is fortunately in an advantageous position in respect of some of the ferrous group mineral as to be able to export them besides meeting indigenous requirements. But vanadium, wolfram, nickel, cobalt and molybdenum required in the manufacture of special steels and alloys are met with only from imports. The reserves of the ferrous group of minerals in the country so far proved are 21,600 million tonnes of iron ores (Hematite & Magnetite), 182 million tonnes of manganese ore, 13.868 million tonnes of chromite, 30 million tonnes of nickel ore, 12,992 tonnes of cobalt, large tonnage of titanium etc. The reserves of wolfram, molybdenum and vanadium have not been estimated precisely. As against this, demand during 1978-79 will be iron ore 73 million tonnes, manganese ore 1.89 million tonnes and chromite 225,000 tonnes. The requirements in respect of other ferro-metals have not been precisely worked out.

An examination of the inventory of the iron ores prepared by the Geological Survey of India and the Indian Bureau of Mines reveals the following gaps. 4,494 M.T. have to be converted from the indicated and inferred category to the measured category and a few deposits have to be proved to meet the requirements of the proposed steel plants and to increase export. Our knowledge about the existence or absence of blue dust in the various deposits, its extent and composition is inadequate as also the iron content in the fines. These deficiencies have to be made up by our future programmes of exploration.

The major problems in the case of iron ore has been the utilisation of large quantities of fines generated in the process of mining iron ore and the natural blue dust. The fines so generated are much larger than the projected demand pattern in the country. It is, therefore, essential that steps are taken for their proper utilisation by sintering/pelletising or manufacture of sponge iron.

So far enough attention has not been paid to the theoretical aspects of iron ore sedimentation in pre cambrians of India. For a better understanding of the character of the various iron deposits, a detailed stratigraphic, palaeogegraphic and geochemical studies of the various iron ore basins is suggested.

The group has made the following recommendations:

(a) Drilling should cover all the blue dust zones in future prospecting. Additional drilling should be taken in areas where blue dust zones were not covered during the earlier drilling .· (Orissa, & Madhya Pradesh).

(b) Study of the chemical composition of the fine and blue dust.

(c) Proving adequate reserves ahead of requirements for steel plants and export in suitable areas.

(d) Study of the Magnetite and Haematite deposits of Sukona sequence in Madhya Pradesh.

(e) Mapping of BHQ and Magnetite quartzite bands.

(f) Palaeo basin & geochemical studies in iron ore regions.

(g) Study of the high alumina content in the iron ores of Orissa, Goa & Mysore.

(h) Production of sponge iron and pre-reduced pellets.

(i) Use of non coking coals for production of iron.

(j) Aerial survey of west coast Magnetite deposits for exploration purpose and air photos with 5 metre contour intervals for project purposes.

Manganese

The *in situ* reserves of manganese ores of all categories are placed at about 106 M.T. located in Maharashtra, Madhya Pradesh, Orissa, Mysore and Andhra. These reserves are of a rather moderate order considered in the background of the envisaged expansion in indigenous steel production. The requirement upto the end of VI Plan period is expected to be about 44 M.T. of manganese ore. At present only 7.6 M.T. are in the measured category and the rest are in the inferred and indicated categories.

The research and development activities should, therefore, include :

(a) Proving adequate reserves for the growing steel industry.

(b) Study of the low grade manganese ore protores and manganiferous shales.

(c) Laboratory and pilot plant studies for the reduction of the phosphorous content of some of the manganese ores.

(d) Pelletization of the beneficated manganese ores.

(e) Study of the ores to be used as raw materials for dry cells.

Chromite

The total reserves of chromite are of the order of 13.86 M.T. located in Orissa, Mysore, Tamil Nadu and Bihar. Of this the four million tonnes proved during the last decade comes entirely from Orissa. The reserves in the measured category are of the order of 4.04 M.T., indicated category 2.52 M.T. and inferred reserves are of the order of 7.3 M.T. Proved lump ore of metallurgical grade is of the order of 0.23 M.T. and fines 1.59 M.T. From the foregoing it is obvious that we have to explore and prove gradewise reserves by drilling all the deposits. Since much of the reserves are of powdery nature, it is necessary to carry out tests for their agglomeration and bonding characteristics. Laboratory scale tests are reported from the R.R.L. Bhubaneshwar but this should be followed by pilot plant studies.

Nickel, Vanadium and Tungsten

(a) To augment the reserves of nickeliferous ores, it is necessary to study all the laterite cappings on all ultrabasics. Nickel and Cobalt association with some of the maganese ores deserve further study.

(b) The vanadiferous and titaniferous iron ores of Orissa, Maharashtra and Mysore, deserve to be assessed in detail to have a reliable data about their composition and reserves.

(c) The Tungsten ores of Kolar Gold field, Bankura, Degana, Agargoan and Nellore have to be assessed by further studies.

Magnesite, Dunite and Dolomite

(a) Studies to improve the recovery of Magnesite from ultrabasic rocks deserve priority.
(b) Manufacuture of refractories from Dunite needs consideration.
(c) Studies for utilisation of limestone rejects produced while screening material for the steel plants deserve attention.

Non-Ferrous Minerals

Platinum

There is no known occurrences of workable platinum deposit in India. However, a large number of ultrabasic bodies with chromite seggregation are known. A systematic investigation consisting of detailed sampling and analysis can be carried out to determine the possibility of occurrence of Platinum. The group of ultrabasics in Salem in Tamil Nadu, Singhbhum district n Bihar and Koenjhar district in Orissa can be taken up for investigation.

Silver

Presently silver is recovered as a by-product of lead-zinc and gold mining. Lead and zinc oncentrates of Zawar, Rajasthan, contain about 774.5 and 171.4 gm. of silver per tonne respecti-ely. Gold ore of Kolar yields about 0.70 gm. of silver per tonne of ore treated, while gold ore f Hutti is reported to contain 0.60 gm. per tonne of ore treated.

The copper ores of Khetri, Rajasthan contain about 0.53 oz. of silver per tonne. The lead res of Cuddapah and Kurnool districts of Andhra Pradesh are also argentiferous.

The grounp has made the following recommendations:—

1. Exploration for new argentiferous deposits should be given priority.
2. Recovery of silver from lead-zinc and copper ores should be attempted, especially from Khetri and Agnigundala projects.

Copper, Lead, Zinc

The position of resources of base metal in the country is substantial as given in the following table :—

	Ore Reserve computed (Tonnes)	Annual metal Production possible (Tonnes)
Copper	245,730,000	81,000
Lead) Zinc)	107,000,000	55,000 Lead 71,000 Zinc

(Source G.S.I., News, No. 12, December, 1971).

It will be clear from the above that the production potential of the established resources is much higher than the actual production achieved. To add to the resources a master plan should be drawn up to coordinate activities of all organisations for a systematic investigations of all reported base metal occurrences, numbering about 900. In addition systematic geophysical and geochemical surveys should be taken up for locating new deposits.

Magnesium

The following recommendations are made:—

1. There are enough resources of magnesium in the country. The reserves of low grade Magnesite, as well as high grade dolomite are ample. Efforts should be made to produce magnesium at low cost from the indigenous raw material.
2. Research work should be initiated to recover magnesium from saline waters of sea or lakes.

Cadmium

The following recommendations are made :

1. Demand estimates should be checked up with actual users to avoid mis-utilisation.
2. Attempts should be made to increase the recovery of Cadmium from the zinc smelters.

Mercury

The following recommendations are made :

1. Search for mercury bearing mineral should be taken up.
2. Research and development work should be initiated to recover mercury from the electrolytic cells, dental amalgams and various types of sludges, Recycling of mercury should be attempted. This research project can be taken up by the universities.

Industrial Minerals

Location of new Diamond occurrences in the Panna belt by sedimentological studies.

The well-known occurrences of diamond in the upper Vindhyan rocks of the Panna bel region are : (1) the various diamond bearing conglomerate horizons and (2) the diamontiferou pine rocks at Majhgawan and Hinouta. The diamonds in the conglomerates differ in physical characters and morphology from those found in the known pipes at Majhgawan and Hinouta. It is likely, therefore, that diamonds in the conglomerates were derived from some pipe(s) other than those known at present. Recently, several Indian geologists have emphasized the strong possibility of presence of more diamontiferous pipes than are known at present. Sedimentological techniques, like palaeocurrent analysis and dispersal pattern analysis, applied to the diamond bearing conglomerates and associated sandstones may provide a clue to the direction from which the diamonds and the associated clastics came. This may lead to the discovery of the locales of diamond concentration which provided the diamonds to the various conglomerate horizons.

Moreover, a systematic effort to delineate the prospective areas of the diamond bearing conglomerates has not been made so far. The prospective areas suitable for intensive exploration can be predicted and marked by finding out the trend and orientation of the daimontiferous deposits by sedimentological techniques. This will help minimise costs of exploration.

The diamond belt of Panna is about 60 miles long and 10 miles wide having an area of 600 sq. miles. It is proposed that the belt be divided into four equal parts. Each year one part of the belt is proposed to be covered and the fifth year will be devoted to the investigations of critical areas. The project is proposed to be executed in the following stages:—

1. Consultation of literature available on the belt and other areas abroad where similar work has been done.
2. A reconnaissance survey of the entire belt.
3. Detailed field and laboratory investigations of each part of the belt.
4. Preparation of drawings, tables and writing of report.

The detailed field and laboratory investigations will cover the following aspects :

a. Mapping of directional structures like pebble orientation and cross-stratification.

b. Mapping of dispersal pattern of clastic particles.

c. Thickness of conglomerate horizons and associated sandstones.

d. Lithologic and sedimentary characters of the conglomerates and associated sandstones.

e. Analysis of palaeocurrent data and preparation of palaeocurrent maps for the entire belt.

f. Preparation of isopach maps of conglomerate horizons and associated sandstone bodies.

g. Analysis of qualitative and quantitative data of sedimentary structures and lithologic features.

h. Petrographic examination of the rocks.

Investigations on industrial utilisation of clays from Andhra Pradesh

The primary object of the proposed research scheme is to make a thorough study of some mportant clay deposits of Andhra Pradesh, *viz.* Dwaraka Tirumala (West Godavari), Rajahmundery (East Godavari), Asifabad (Adilabad District), Srirangpur (Mahboobnagar District), Shekhpur (Medak District) and Chintryal (Nalgonda District). The minerals that contain extractable metals play an important role in industrial development. Similarly minerals without have a wide applicability in industries like ceramics, paper, electrical, cement, iron and steel, petroleum and foundries, etc. as refractories and catalyst.

Though the clays are utilized in various ceramic industries, their actual quality in relation to their physico-chemical characters is not much known. Clays from most of the above mentioned areas except from Dwarka, Tirumala, are being either improperly used or not exploited properly due to lack of knowledge on their industrial potentialities. In almost all these cases, detailed investigations based on modern trends of study of clays and clay mineralogy are required for proper evaluation of these clays and their utilization. Hence the present project is proposed to take up the studies to classify and grade them according to their industrial utilization character.

The following is a brief account of various aspects of study that will be undertaken :—

1. A systematic geologic mapping of different areas to delineate the clay deposit horizons.
2. A systematic collection of clay samples from different levels of the formations.
3. Determination of physical properties of clays porosity, plasticity, moisture content loss on ignition, shrinkage, specific gravity, P. C. E. value etc. under different temperate and pressures as described in Indian Standards specifications for moderate and high heat fire clay refractories.
4. D. T. A. and X-ray analyses of the samples and identification of the individual clay minerals along with the associate impurities.
5. Determination of Ph. and chemical analysis.
6. Studies in the methods of washing and development of the clays.

The petrographic studies of coal as guide to selective preparation, beneficiation and carbonisation

Coal petrography has been applied in many fields of investigation particularly in the utilisation of coal for coking. Coal being a hetrogenous material comprising both inorganic and organic components, it requires careful circumscription and assessment in order to understand its technological behaviour. Microscopy is an aid for such studies. The rapid advances in coal macerals studies in the last two decades have paved the way for modern developments in the applied field, particularly in regard to the measurement of reflectivity of coal macerals which provides an accurate method of defining 'Rank'. It is in the last decade that intensive work in Russia, America, Europe has provided the rational explanation of the behaviour of coal on carbonisation based on petrographic parameters.

It is proposed to undertake the macerals studies together with the reflectance measurement for the purpose of characterising coking propensities of coal and determining the preparation of coal and of reactible units within a blend; in the reflectance measurement the modren mechanical and electrical aids will have to be used for expeditious assessment.

It is proposed to undertake the characterisation of coking coals and other coals with a view to correlating their properties with selective preparation, beneficiation, coking, etc. It is intended to evolve finally a code index of Indian coal for such utilisation studies. Pilot plan facilities for these studies exist at CFRI and is valued at more than rupees one crore.

Stratigraphic, Tectonic and sedimentalogical framework of Peninsular Gondwana Basin

Basin analysis can aid in prediction of both regional and local sedimentary trends in exploration for coal. Thus an integrated study of basin tectonics, dispersal pattern stratigraphic attributes may unravel the sequence of events that were operative during the formation of coal and associated sediments. Never before an attempt was made to collect and collate the surface and subsurface data on regional scale to promote the understanding of the factors which were instrumental for the variations in the character of the coal seams. Moreover, the concept of the coal deposits as a "population" is a relatively modern concept and this approach tends to emphasise operational definitions of rock properties, their measurements and statistical analyses. Coal deposits are also looked upon as chemical entities and products of biochemical decay of vegetal debris. Thus an understanding of coal formation calls for a multi-disciplined approach to problems connected with it. Therefore, from an integrated study of both field and laboratory data from various fields it will be attempted to decipher the (a) stratigraphic differentiation and zonation of the lithologic units developed in various basins (b) role of tectonism in and around the depositional areas and its influence on sedimentation (c) the nature of the sedimentary processes and the environments controlling it. The most important problem is to evaluate the nature of variations in coal seams both in quality and pattern of development in space and to what extent these are influenced by sedimentary and tectonic processes.

In this project it is proposed to:—

(1) Delineate the lithostratigraphic boundaries in the different basin belts along with a synthesis of the structural framework.

(2) Study the scalar and vectoral properties of the sediments.

(3) Prepare isopachs and facies maps on the basis of subsurface data.

(4) Systematic sampling of the litho units both from surface as well as from borehole cores.

(5) Study of the petrography as well as other sedimentalogical attributes like sphericity, roundness and grain size.

(6) Collation of the data on petrography, lithic attributes and directional properties which will give an insight into basin filling and preparation of a facies model.

Integrated studies for Regional Assessment of the Aravalli Mineral Belt

It is proposed to carry out gravity, magnetic and other conventional methods of regional appraisal nature in the well-known mineral-rich zones of the Aravallis. The planning of these surveys will take into account the existing as well as available aeromagnetic and other airborne data in this region. The geophysical surveys will be supplemented by geochemical and structural studies where necessary and also laboratory investigations such as measurements of physical properties of rocks, analyses of the collected data using modern and improved techniques and electronic computers. It is expected that such an integrated approach in the Aravallis which are the major source of supply of asbestos, soap-stone, copper, lead, zinc, etc., to this country, will lead us to locate and exploit the rich mineral potential in this part of the country.

Regional Gravity Magnetic and Radiometric surveys over an intervening zone between Cuddapah and Pakhal Basins of South India

The project envisages the preparation of gravity Bouguer anomaly map and vertical magnetic intensity anomaly map in the scale of 1 : 2,00,00 over a mineralised and structurally interesting area lying between 79°30' E to 81°E longitude and 16°N to 18° latitude in Andhra Pradesh. The area is composed of Archaean—Proterozoic rocks. The younger sediments in the region belong to Gondwana system which are coal bearing. Large scale mineral deposits, both metalliferous and non-metalliferous are also known to occur in this area.

The Geophysical surveys will be carried out to serve the following problems:—

(1) In demarcating structural, lithological and tectonic zones which are favourable for ore deposition;

(2) In delineating intensive bodies which are of significance in metallogentic forecasting since in a number of cases the ore minerals are found associated with them;

(3) To separate areas which appear to be barren from those which appear to hold promise of mineralisation for further detailed geophysical surveys; and

(4) Radiometric surveys for the search of radioactive minerals in the area.

Precambrian Geological Investigations

The problems of Precambrian Geology of Peninsular India constitute a unique and important class of fundamental interest and their study promises to have valuable application to problems of mineral exploration in this region. Not only is this area, the seat of one of the oldest cratons, but it presents an archetype of precambrian environment about which little is known. It presents the whole gamut of rock types with sedimentary and igneous associations and all grades of metamorphism, and geological ages ranging from the oldest Precambrian to Eocene. The geological, geophysical and geochemical problems of this area have to be considered in the light of a synoptic, integrated approach.

From the view point of economic geology, the following questions demand systematic and organised study.

The Indian shield has a variety of rock units of ages varying from Precambrian to Eocene, and data on the ages of emplacement of various rock types and the metamorphic episodes to which they have been subject, are vital to mineral prospecting. Work in ore field regions in other continents has shown that a series of metasomatizing events involving the ascent of ore-carrying hydrothermal solutions can be recognized in any geologic province, and such maxima of hydrothermal activity bear an intimate relationship to episodes of primary and rejuvenatory mineralization. Again, the relationship of shield on cratonic margins to sulfide ore deposits by virtue o seabourd volcanism and replacement reactions of the accompanying halides sediments o the off-reef facies, has been demonstrated. This suggests the delineation of cratonic margins a an aid to ore-prospecting.

Closely related to this are sulfur, carbon, and oxygen isotope studies on the abundan minerals of this region. As such isotope abundance variations are geological indicators of (a) th source materials (b) the physicochemical conditions prevailing at the time of mineralisatio Thus sedimentary association is revealed by (S^{32}/S^{34}) ratios, as also information on horizonta and vertical migration of ore solutions. ($O^{18}/^{16}$) ratios provide data on geothermometry an (C^{12}/C^{13}) on biogenic origin of carbonaceous material.

A systematic study of trace elements in the ultrabasic rocks of this area, is in order as these are likely to prove useful sources of Ni and Pt-metals.

In view of the known occurrences and established facilities for copper mining in this region, investigations on hydrometallurgical recovery of Cu and S are of paramount importance. A special feature of these recovery processes is the avoidance of environmental pollution.

There is also need for creation of smelter facilities for concentrates of minerals and R&D work bearing on this problem.

Genetic studies of the mineral sands occurring along the Kerala Cost

The black sand deposits occurring at many places along the coast of Kerala and Kanyakumari district of Madras coast form the richest known deposits of its kind in the world. The sands mainly consist of Ilmenite, Monazite, Rutile, Zircon, Sillimanite and Garnet in large amounts and Kyanite, Andalusite, Thorite, Uraninite etc. in traces. The sands are being mined and separated into its various constituent minerals by mechanical processes in the mineral factories. Ilmenite and Monazite are being processed in India.

In a broad way the sands are known to be derived from the Archaean rocks and their lateritised products and from the younger sediments. Previous studies of the sands have generally been of a quantitative nature dealing with the tonnage available and the approximate percentage of each mineral in samples from many of the places along the coast and no attempt has been made to study the genesis of the minerals that are found to constitute the black sand deposits.

Reconnaissance of selected areas in the Western Ghats and the foot hills extending in Southern Kerala and Kanyakumari district would be undertaken. Field examination would be undertaken of: (1) Archaean metamorphic rocks such as the charnockites, garnetiferous gneiss, Khondalites, veins, pegmatites, etc., (2) Laterites, (3) Tertiary sediments and (4) Recent Sediments. . Collection of samples from the above and also from river beds and coastal deposits.

Revision of Precambrian stratigraphy and structure of Southern and Central Rajasthan

Intensive studies during the last two decades in the Precambrian shield areas of the world have shown that structurally and stratigraphically they are much more complex than it was formerly believed to be. Radiometric data and comparison with other Precambrian shields led to the suggestion of a number of Precambrian organic cycles in India. In the Precambrians of Rajasthan, the Delhi cycle is believed to represent a Proterozoic orgency, whereas the older Aravalli cycle is taken to the equivalent to the Dharwar cycle of the Eastern Ghats cycle.

The primary scientific objectives of the study will be (1) to clarify the relation between the metasedimentaries and the gnessic rocks between Kherwara, Iswal, Salumbar, Nathdwara and Darauli in the Dungarpur and Udaipur district; (2) to find out the interrelation between the Delhi System and the Aravalli-Raialo groups in certain key sectors like near Udaipur, between Gogunda and Amet, and selected areas between Deogarh and Beawar. Emphasis will be given to the style, sequence and orientation of deformation structures between the supposedly unconformable groups, stratigraphic breaks if any between and within the groups, and relation between the different metasedimentary groups and the gnessic rocks. The lithological variation within the Aravalli System between Nathdwara and Udaipur will need special examination.

Structural studies in the Precambrian Rocks of Krishna, Guntur and Khammam Districts

Parts of Khammam, Krishna and Guntur districts of Andhra Pradesh reveal a tectonic history which is most interesting from the point of view of mineralization. Some of them are very well known such as the Agnigundala copper-lead belt, the Chromite of Kondapalli and Khammam, Copper in Mailaram, graphite in Khondalites of Eastern Ghats etc. However, a survey of literature shows that the delineated zones from the structural standpoint are fragmentary and imperfect.

The objective of the present investigation is to systematically map all the interesting areas, the emphasis being on intense structural studies at different levels. Such a detailed structural analysis in select areas where mineralization has been reported, would lead to a regional build up of all the mineralized belts and an integrated picture where prospecting can be taken up at a future date. From the point of view of studies of this kind the area is one of the classic regions in Peninsular Shield of India as it has received the impress of successive episodes of tectonism, metamorphism and magmatism with related mineralization.

The area has been under study of a considerable length of time and the Geological Survey of India has done good work particularly in connection with the economic mineral deposits.

The present research scheme consists of the study of the following :—

(a) A detailed investigation of the structure of the sulphide deposits of Angigundala in Guntur district and Mailaram in Khammam district and the barite deposits in Khammam district.

(b) Deailed study of the ultrabasic rocks and the associated chromite deposits present in Lingampet-Enukuru area in Khammam and Kondapalli hills in Krishna districts with special reference to their structural control and extent.

Soft Ware Development for Mineral Exploration Studies

Since the expertise in the field of data processing is still not developed on a large scale. and it is envisaged that in the near future, date processing has to be developed for its use on a wide-spread basis, it is essential the talent available should be pooled for the development of necessary soft-ware in this field.

Some computer programmes are already available which are of use in mineral exploration. It is, however, necessary to program for optimal filters for spatial spectrum studies which will help in discerning the patterns of mineralization in many base metal deposits. Multi dimensional scaling methods would help in identifying the patterns of mineralization and this requires large scale programming effort. It is also necessary to develop three dimentional spectral analytic methods so that borehole data can be studied in a more vigorous manner. Canonical methods of analyses have to be tested for their utility in data processing. It is also necessary to develop soft-ware in the branches of simulation of stochastic and markovian phenomena. Deterministic, Semideterministic and probability models need be constructed to study the behaviour of process response model. Processing of airborne survey data and remote sensing data need sophisticated soft-ware packages. It is hoped by this collaborative effort, such packages can be devolped.

Thermodynamic properties of important mineral group

Physical geochemistry involves the study of the physico-chemical processes in the earth's crust which give rise to rocks and mineral deposits. The chemical processes are heterogeneous equilibria involving solids, such as equilibria or homegeneous equilibria that take place within the mineral phases. If suitable thermodynamic data on the various phases participating in a chemical reaction are available, the direction of the reaction at any given time can be predicted. Unfortunately the thermodynamic data on minerals is meagre because the procurement of such data either experimentally or theoretically is beset with difficult problems. In minerals, atoms are bonded by several type of forces and their composition varies within wide limits. In order to know their thermodynamic nature, it is necessary to study both the nature of the internal forces in individual crystal and their macroscopic behaviour in chemical reactions in experimental or natural mineral assemblages. Studies such as the intracrystalline distribution of atoms and the intercrystalline ion-exchange in geological processes give us a greater insight into the thermodynamic properties of minerals. A knowledge of such properties is a basic requirement for all scientific inquiry into the nature of chemical process forming rocks and mineral deposits.

Thermodynamic properties of minerals which are often crystalline solutions of various endmembers may be determined indirectly by the study of phase equilibria and inter-crystalline action distribution among co-existing phases (Silicates and Ore minerals) either in natural assemblages or in experimental systems. The following projects will be considered :

(a) The study of co-existing minerals from well crystalline metamorphic rocks and other mineralised areas to be continued to understand the behaviour of the multi-component systems at different pressure and temperature conditions. High grade metamorphic rocks such as charnockites from South India are especially suitable for chemical study of phase equilibria natural systems.

(b) Numerous experimental phase diagrams are available in literature for theoretical evaluation of thermodynamic properties of minerals. These properties such as the Gibbs free energy of mixing in a mineral may be obtained in suitable cases from data on phase-equilibria.

(c) Phase diagrams for petrologically important binary crystalline solutions are available in some cases. Computer programmes are to be developed which will enable us to study both binary and ternary crystalline solutions for many important rock-forming minerals and ores.

Integrated studies on the Deccan lava flows

It is proposed to study intensively the Deccan Trap formations. A multi-disciplinary approach will be taken up through integrated geophysical, geological, geochemical and geochronological studies of this extensive lava flow. The nature of the variation of different parameters between one flow and another throughout each flow are sought to be studied.

Of the recent lava flows on the earth surface this is one of the largest basaltic emergences. Its study has a basic relation with the tectonics of earth during that period. A detailed study will delineate fundamental information about the physico-chemical processes that dominated this region of the earth during the geologic era. Runcorn (1971) has suggested its investigation in light of plate theory and reports that it may also aid significantly towards our understanding of mineral occurence as well.

The Koyna earthquake zone on the relatively stable shield falls in the region. The study has thus added significance to substantiate the understanding of weak zone activity in this area. Following studies will be carried out:

1. *Geological* :
   - (a) Petrology, mineralogy.
   - (b) structure, stratigraphy, geomorphology and hydrology.
   - (c) Radiometric dating by Fission track techniques.
2. *Geochemical*
   - (a) Major minor trace elements and elemental and oxide ratios in relation to petrology, and mineralogy.
   - (b) Significance of important ratios like K/Rb, Rb/Sr, Pb/U, K/Na, etc.
3. *Geophysical*
   - (a) Gravity.
   - (b) Airborne magnetometric (multi-altitude) and scintillometric (broad band) survey-profiles across the Deccan Traps.
   - (c) In situ estimation of U, Th and K with a portable gamma-ray, scintillation spectrometer.

SUB SECTOR : WATER RESOURCES :

Water resources constitute the most important assets of a country. India with its geographical area of 3.27 million square kilometers has been endowed with water resources of nearly 1700 billion cubic meters. With the vast population of 550 million, the optimum use of our valuable water resources assumes great importance. An accurate assessment of water resources is an essential pre-requisite in any scientific planning for the exploitation of the water resources for the benefit of mankind. The development of water resources call for very careful planning and evaluation as each water development project encounters a unique set of physical conditions to which it must conform. Standard designs can rarely be used and the special condition of each project must be met through an integrated application of the fundamental knowledge of many disciplines. Research has been an integral part of water development activities in the world and is of immeasureable value in reducing cost of development.

Rainfall over tropical India is more or less synonymous with monsoons. The total seasonal or monthly rainfall in the monsoon season will indeed be of importance from the point of view of storage of water in reservoirs and for overall hydrologic planning. The average volume of water that one monsoon pours over India (excluding J & K and Himachal Pradesh) during the monsoon season (June to September) has been estimated to be 2396×10^9C meters (1940 MAF). This contributes enormously to the water resources of the country and for optimal utilisation and development of such vast natural resources, it is imperative to make exhaustive analysis of the available precipitation data, its variation, time and spatial distribution.

In any region, the annual input of precipitation consisting of rainfall and snowfall is not constant either in quantum or in time-wise and spatial distribution. Precipitation being an unpredictable variable, a methodical measurement of the input along with measurements of the components into which it gets distributed is the most essential firststep. Without such methodical measurements, the assessment of water resources based on assumed analogies and empirical fomulae will be inaccurate and any development based on an inaccurate assessment can cause or create avoidable problems in the long term planning.

It is estimated that nearly 100% of annual precipitation in arid zones and about 70% to 75% in humid zones is lost through evapo transpiration. In recent years evapo-transpiration has been receiving increased attention by hydrologists, meteorologists and agronomists. Significant developments in instrumentation and computational techniques aided scientists in conducting research in this important area. Though some work has been done in this direction in our country, these are in general empirical and are at best good for estimating "potential" evapo-transpiration rather than actual evapo-transpiration. There is a need for increased research in this area so as to be able to estimate evapo-transpiration more accurately.

Besides estimating evapo-transpiration, efforts must also be made to minimise the loss of water back to the atmosphere. Except for a few experimental studies of academic interest, no effort is made to reduce evaporation from lakes and reservoirs. Use of chemical monolayer films (such as Hexadecanol, catyl alcohol, glycol etc.). need to be tested and employed extensively to conserve water from the reservoirs. The effectiveness of these mono-films depends on several factors such as solubility, wind action, method of application, oxidation and degradation by micro-organisms etc. It is estimated that normal evaporation may be reduced by as much as 33 per cent by efficient use of monolayer films. This is one major area where the research effort is either absent or at a minimal level and consequently needs strengthening. Thus, the two most important aspects of further research shall be assessment of evaporation and evapo-transpiration based on more rational procedures rather than empirical correlation and the reduction of evaporation from free water surface through effective use of chemical films. Procedures such as mass transfer methods and energy balance methods should be adopted appropriately for the estimation of evaporation. Similarly lysimeter studies are to be initiated in different climatological regions of the country. In order to conduct water balance studies of major and minor river basins, river resources evaluation and planning directorates have been proposed. The main role of these directorates would be to (i) organise the collection of river flow data continuously and systematically; (ii) keep records of the man made changes in the catchments; (iii) compile the ground-water level data from CGWB and precipitation data from IMD and (iv) organise management of water resources in the basin.

The sediment and detritus transported by the rivers either in suspension and/or along their beds have an important bearing on engineering projects relating to storage, flood control, soil conservation, navigation etc. The reservoirs behind the dams get silted up leading to reduction in their capacity and functional utility. The sediments cause the river beds to silt up and increase the flood heights consequently inundating the fertile lands. They also choke up the navigation channels, ports and harbours as well as irrigation channels and decrease their utility.

In India, the field of sediment study is a large one because of the great diversity in the ranges of rivers discharge, slopes and sediment grades, etc. The methods for collection of sediment samples and analysis employed by the various agencies/departments of the country are anything but uniform. Sediment studies are not done on a regular basis along with discharge and very often these are based upon the results of a few samples collected haphazardly from some points near the surface and other places. There is an urgent need for standardizing the collection and analysis of samples and studies on a rational and uniform basis.

Remote sensing techniques have been adopted in the area of water resources, which include conventional black and white aerial photographs taken at appropriate periods. In special problem areas study may have to be carried out using not only ordinary aerial photography or colour photography etc. but these studies have to be correlated to thermal and SLAR imagery to get precise knowledge and to facilitate analysis, as this forms the methods of indirect observation. Apart from this, the imagery obtained from satellites will not only be useful but could cover larger areas in a short time to arrive at conclusive results. Without normal aerial photography in black and white, results may not be conclusive as other forms of imagery only supplement information.

Water resources engineering is presently emerging as a dynamic branch of applied science, extensively drawing upon the progress made in basic sciences and systems engineering. The advent of electronic computers has given tremendous impetus to the simulation of the physical phenomena and the natural systems through mathematical modelling. The critical analysis of the components and the optimal design of the overall system through computerisation is now a technical feasibility. To take advantage of these modern techniques to solve the complex problems of water resources engineering, there is an urgent need to step up the use of electronic computers in India.

The assessment and development of water resources, in all their phases of investigations planning, designing, construction and operations, require instrumentation for measurement of a wide spectrum of parameters. There is thus a great need of R & D work for instrumentation in this field.

During the last two decades, though a lot of work has been done towards the development of irrigation facilities to bring more and more cultivated area under irrigation but still only about one-fourth of the cultivated area has been brought under irrigation. Thus great emphasis is required to be placed on planning and development of water resources and water resources projects. Planning of any type or nature can only be undertaken on the basis of accurate data. Hence, proper collation, storage and retrieval of data in the water resources sector assumes great importance.

Geotechnical studies in water resources development have assumed great importance. In the earlier era water resources developments were restricted to storage dams in the better geological sites, but now high dams are contemplated in the mountainous regions with complex geological structures susceptible to strong earthquakes. The regions are also subject to major land slides. These land slides, in addition to the threat they pose to the structures, have pronounced effect on the sediment transported by the rivers and have in many cases led to catastrophic floods. There is thus a need for proper investigation techniques and assessment of behaviour of rock masses.

The component of precipitation and surface water spread that seeps down below the surface of the earth to get partly accumulated as storage and partly regenerated as drainage constitutes ground water resources. Groundwater development aims at bringing this component back to the surface of the earth at desired locations.

Assessment of groundwater resources differ from other mineral resources in the sense that it gets replenished and therefore a perennial supply can be assumed provided a balance between utilisation and replenishment is maintained.

Geophysical investigations can be used with great advantage in a variety of geohydrological problems ranging from direct and indirect location of groundwater to direct determination of hydrological parameters correlation of aquifers, identification of aquicludoes and a host of engineering problems connected with hydraulic projects. Although geophysical investigations must play a very crucial role in all stages of ground-water development *i.e.,* exploration management and exploitation, their application in this field has been paradoxically on the fringe both in regard to the volume of geohydrological investigations undertaken as well as to the volume of information content of the geophysical data collected and utilised. This situation arises from want of easy availability of suitable geophysical equipment on the one hand and from an unsorted maze of geophysical methodologies, particularly in electrical prospecting, on the other; that are suitable for hard rock area, arid zones and sedimentary basins.

Most troublesome water shortages have occurred in places of apparent abundance. In shortage areas the key to minimising the impact of drought would be to provide the capacity to store water during the period of abundance. The extremely intricate acquifer systems below the ground level present the need for study in depth, of its capabilities in these directions.

The quality of ground water to be free from harmful level of contaminants is essential. This could be initiated by monitoring of groundwater quality with respect to toxic ingredients and flourides. Such studies could be started in the first instance in areas with high incidence of chemical pollution such as places of intensive application of fertilisers, pesticides, wastes from tanneries etc. Simultaneously, these studies could also include an assessment of the beneficiary effects of adsorption by top soil.

The analysis of ground water availability and conjunctive ground water and surface water use, can generally be divided into two broad categories. These are :—

(i) the identification of the aquifer parameters and subsurface water level logging and

(ii) the economic management of the aquifers in conjunction with surface water. The aquifer parameters of the ground water body which must be identified are the storage coefficient, the transmissibility, and the boundary configuration of the aquifers as also their hydrologic evaluation in terms of quantitative parameters. Knowledge must also be obtained on factors, such as the rate of natural replenishment of the ground water, the patterns and velocities of ground water flow, chemical quality of water, and changes in water levels that occur as a result of the natural pattern of ground water movement and pumping from wells. Similarly, concentrated research on the methodology and instruments for collection of data and carrying out investigation is *sine quo non* for the success of the programmes.

Integrated water resources development should include basin-wise approach where ground and surface water are treated as complementary. R&D needed to develop national and regional water grids has also been considered by the planning group. R&D has also been aimed at reducing irrigation losses and reuse of water presently consumed for sanitation purposes. It is also expected to affect improvement in the overall management of our enormous water resources of the country.

The R & D projects identified in both surface and ground water involve an outlay of Rs. 93.26 crores in the following broad areas:

TABLE I

Sl. No.	Sub-Committee	Financial Outlay (Rs. in lakhs)
1	2	3
1.	Precipitation snow, glacier study.	100.00
2.	Evapotranspiration, run-off recharge floods.	525.00
3.	Sediment and Water quality observation.	1820.00
4.	Aquifer identification and sub-surface water level-logging.	300.00
5.	Hydrometry.	1920.00
6.	Computerisation, Mathematical Modelling and simulation.	370.00
7.	Satellite and remote sensors.	93.00
8.	Instrumentation.	200.00
9.	Data processing, collection, storage and retrieval.	34.00
10.	Hydraulics, hydraulic structures.	283.50
11.	Engineering geology, geohydrology, geophysics, geochemistry, seismology.	165.50
12.	Agriculture, soil water plant research, irrigation, water management and drainage.	266.00
13.	Materials, Soil, Concrete, Rock.	800.00
14.	Water pollution, control and monitoring water conservation reuse research.	800.00
15.	Sedimentation, watershed management.	660.00
16.	Hydromechanical equipment.	90.00
17.	Hydrogeology.	90.37
18.	Groundwater geophysics.	198.09
19.	Groundwater Hydrology.	110.44
20.	Groundwater Engineering.	500.00
	TOTAL	9325.9

The various projects, under the subsector water resources are indicated below :—

Project Index No. S_iG P_k	Title of the Project	Financial outlay (Rs. lakhs) Total
1	2	3
$S_2G_5A_1$	Precipitation, snow and glacier Study	100.00
2	Evapotranspiration, run off, recharge and floods	525.00
$S_2G_5A_3$	Sediment and water quality observation	1,820.00
4	Acquifer identification and surface water level logging	300.00
5	Hydrometry	1,920.00
$S_2G_5A_6$	Computerisation, mathematical modelling and simulation	370.00
$S_2G_5A_7P_1$	Sediment studies in the Bhakra Dam and Nizam Sagar catchments	23.00
2	Study of water logged areas of Haryana, Punjab and West Uttar Pradesh	21.00
3	Water Harvesting—Study of pilot areas for feasibility of water harvesting and potential therein by Remote Sensing techniques.	44.00
4	Flood control measures in the Alaknanda, Kosi and Gomti Rivers	5.00
$S_2G_5A_8$	Instrumentation	200.00
$S_2G_5A_9P_1$	Setting up of National Water Data Bank	10.83
2	Statistical Cell in IMD	6.87
3	Statistical Cell in CGWB	2.57
4	Statistical Cell in Soil Survey Organisation	2.30
5	Statistical Cell in GSI	2.61
6	Statistical Cell in Survey of India	6.10
7	Statistical Cell in CPHEEO	2.72
$S_2G_5A_{10}P_1$	Energy dissipation arrangements and study of scour phenomena	50.00
2	Study of cavitation on hydraulic structures and preventive methods	10.00
3	Open channel flow including sediment transport	74.00
4	Study of pipe flow including method of reduction in losses	16.00
5	Hydro-elastic vibrations	12.00
6	Development of analytical methods of structural analysis related to dam and allied hydraulic structures—static and dynamic.	33.00
7	Development of model and experimental methods of analysis of structures	56.00
8	Study of prototype behaviour of dams and hydraulic structures and method of restoration and strengthening.	22.50
9	Optimisation of the use of materials and technique for river valley structures including use of pre-stressed and precast technique—system analysis.	10.00
$S_2G_5A_{11}P_1$	Studies of geotechnical problems of national importances	50.00
2	Engineering seismology with special reference to river valley projects	62.40
3	Studies in interference problems in geohydrology	2.40
4	Investigation and development of groundwater resources in West Bengal	6.00

1	2	3
5	Geotechnical studies for evaluation of movement and stability of rock masses . .	22.70
6	Regional studies of land—slides	22.00
$S_2G_5A_{12}$	Agriculture, soil, water, plant research, irrigation, water management and drainage .	266.00
$S_2G_5A_{13}$	Material, soil concrete, rock	800.00
$S_2G_5A_{14}$	Water pollution, control and monitoring water conservation, re-use research . .	800.00
$S_2G_5A_{15}P_1$	Reservoir Surveys	130.00
2	Silt and discharge gauging scheme	530.00
$S_2G_5A_{16}P_1$	Development of designs for high head gates	16.00
2	Design development of large valves for control work	16.00
3	Survey of requirements of designs, development of impellar designs and auxiliary equipment.	46.00
4	Operating experiences and prototype behaviour observations	12.00
	Total : Surface water	8,427.00
	A-17—Hydrogeology	
$S_2,G_5A_{17}P_1$	Study of hydraulics of open wells/tube-wells leading to the theory of pump test for evaluation of hydraulic characteristics of aquifers specially in the hard rock areas.	*45.00
2	A study of the recharge conditions to the groundwater bodies during different seasons of a year on account of the existing tanks on different rock formations around Petlawad and Jobat towns.	19.19
*3	Hydraulics of wells and aquifers in Deccan Trap formation	*6.18
*4	Studies on the possibilities of artificial recharge of groundwater in the semi-arid to arid tracts of India (Eastern Rajasthan and Delhi in the first phase).	*7.03
*5	Mathematical and analogue models in groundwater systems	*4.30
6	The study of joints and fracture patterns and other diastrophic structures in Precambrian rocks of Purulia Distt. (WB) and adjoining areas in Bihar for location of sub-surface water.	1.50
7	Exploration and development of groundwater resources in hard rock areas of India .	7.17
	A-18—Ground Water Geophysics	
$S_2,G_5,A_{18}P_1$	Running of one year diploma course in ground water geophysics of Osmania and Roorkee Universities.	28.54
*2	Development of 3 types of electronic instruments that will be useful in groundwater exploration.	*16.50
*3	Development of instrumentation, methodology and interpretation techniques in multifrequency electromagnetic depth sounding for hard formations.	*8.40
4	Geophysical instrumentation for exploration of groundwater resources	8.00
5	Study of the potentiality of electromagnetic depth sounding and its application in groundwater exploration.	5.00
6	Geophysical study of hydrological conditions in Precambrian metamorphics, Gondwana basins and Indogangetic alluvium of Bihar.	4.00
*7	Development of a responsive seismic and electrical methodology for geohydrological problems in metamorphic areas.	*4.12
*8	Seawater-Freshwater relationship in the coastal area of Andhra Pradesh . . .	*4.00
9	Development of improved methodology and interpretation techniques for electrical sounding in soft formations.	4.50
10	Delineation of seepage zones in embankments by geophysical methods . . .	5.30

1	2	3
11	Development of methodology for integrated geological, hydrogeological and geophysical investigations for groundwater in parts of West Godavari Distt. Andhra Pradesh.	17.40
*12	Exploration and Management studies of groundwater resources	*80.00
*13	Development and adaptation of geophysical methodologies as an intrinsic component of integrated geo-investigation in geophydrological problems calling for a coordinated effort-simulation of aquifers.	*5.65
14	Integrated Surveys of Water Resources in Eastern Ghat region of Andhra Pradesh . .	6.68
	A-19—Ground Water Hydrology	
$S_2G_5A_{19}P_1$	Radio Isotope and nuclear instrumentation studies in geo-engineering with reference to groundwater in A. P.	*9.00
2	Survey of Himalayan Glaciers for water source	9.54
3	Groundwater exploration assessment and development in hard and soft formation . .	6.00
4	Groundwater potentialities in Jabalpur Distt	0.19
5	Hydrogeology and geophysical exploration for ground water in parts of Dharwar and Raichur Distt. in Mysore.	2.50
*6	Increasing groundwater storage	*50.00
7	Investigation of groundwater resources in parts of UP and Bihar . . .	6.34
8	Study of geological and environmental control on pollution of G.W. with special reference to toxic substances and components hazardous to health	6.37
9	Groundwater movement and extraction potential by geohydrological methods, based on mathematical modelling, simulation and allied techniques	5.00
*10	Aquifer evaluation and management in selected areas of Deccan/Maharashtra by digital and analog models.	*6.00
*11	Salt water intrusion into coastal aquifers	*9.50
$S_2G_5A_{20}$		
*1	Groundwater Engineering	*500.00
	TOTAL :	898.90

*Asterisk denotes priority projects.

Ground water

Highlights of important projects

Water Resources (Surface Water)

Some of the important R & D work proposed to be undertaken under the various sub-committees are given below:—

A. ASSESSMENT SUB-SECTOR.

1. *Precipitation, Snow and Glacier Study* :

Precipitation data is already available in punched cards and they will be used for the stochastic analysis. The steps include:

(a) Collection and compilation of available data.

(b) Collection, compilation of available programmes for stochastic analysis of precipitation data.

(c) Formulation and testing of stochastic models for time series at a point, in a basin, and between two or more series and development of new programmes when necessary.

(d) Using verified models, analysis of data for India on a broad basis.

(e) Preparation of precipitation variability maps on a stochastic basis.

(f) Development of operational radar system from the stage of manual analysis to a semi-automatic system and later to a fully automatic one.

(g) Digitalization of cloud photographs and production of composite maps of snow and ice fields by the use of satellities. The satellites have capability of measuring the area covered by snow in remote areas. The cloud patterns have revealed tha satellite pictures can be quite critical in determining the possibility of forecasting the timing and intensity of heavy rainfall. The study of infrared radiation data is one of the interesting applications of satellites to hydrology.

New sensors to increase the capabilities of satellites are being built in the future satellities which will bring further significant increases in its benefit to hydrological forecasting. The new radiometers are expected to delineate field of flooded area with much more resolution than before. Therefore, if we develop the capabilit in assimilating and using the data attained from satellite, the satellite application have a large potential in hydrology.

(h) Intensification of numerical methods of forecasting already being done.

(i) Conducting experiments on dynamic cumulus modification technique and augmen ing research being carried out by I.M.D. and I.I.T.M.

(j) Development of instruments. The development of raingauges and the snow-gauges particularly for remote locations is an urgent necessity for hydrologists. Radio reporting raingauges are being developed by India Meteorological Department. It is necessary to adopt the latest development in technology and the possibility of adopting sophisticated remote control electronic gauges. The development of suitable telemetering equipment and improvements in the accuracy of the radio reporting raingauges and snow-gauges are to be adopted in the field of development of instrumentation.

(k) Fixing value of precipitation data for different hydrometeorological regions.

(l) Testing the adequacy of existing network and instrumentation; and when necessary designing suitable network.

(m) Publication of manuals and atlases for precipitation in India and its use in the design of water resources, agriculture, drainage, and other systems.

(n) Setting up of snow course, observatories, etc. in an experimental snow bound catchment. Collection of data and analysis for correlation of various factors.

2. *Evapo-Transpiration, Run-off, Recharge and Floods*

The following specific aspects in the areas of evapo-transpiration, recharge, run-off and floods have been suggested for detailed study:—

(a) *Evapo-Transpiration*

(i) Assessment of evapo-transpiration,

(ii) Control of evaporation from lakes and reservoirs.

(b) *Ground Water Recharge*

(i) Assessment of natural recharge in river basins.

(ii) Inter-basin transfer of recharge,

(iii) Quality of recharge,

(iv) The mechanism of the process of infiltration under various soil conditions and water supply conditions,

(v) Evaluation of recharge characteristics of soil and aquifer media.

(vi) Economics of different methods of artificial recharge under various soil conditions.

(vii) Economics of conjective utilisation of ground water and surface water artificially induced recharge to the aquifers.

(c) *Run-off*

(i) Effect of man's activity on mean and extreme values of run-off well as base flow.

(ii) Run-off simulation models for pilot catchments.

(iii) Quality of water and its effect on choices for the use of water.

(iv) Sequential generation or time series analysis of runoff data.

(v) Runoff and sediment transport.

(vi) Snowmelt and run-off.

(d) *Floods*

(i) Flood prediction models for flood forecasting purposes,

(ii) Management of floods by structural and non-structural measures such as dykes, dams, flood regulation, flood zoning etc.,

(iii) Statistical analysis of flood data,

(iv) Relation of statistical models with the physics of hydrological events,

(v) Flood damage and its evaluation for a catchment,

(vi) Effect of floods on replenishment of soil in terms of agriculture,

(vii) Effect of floods on sediment transport in the rivers,

(viii) Mechanics of flood plain formation.

For this purpose the following activities are envisaged:

(i) To collect accurate hydro-meteorological data continuously and systematically in all major river basins in the country.

(ii) To publish the above data so collected from time to time such that they are readily available for planning water utilisation of the river basin concerned.

(iii) To launch research programmes to bridge the gaps in scientific knowledge and understanding of both the static and dynamic balances involved in the occurrence, distribution and transport of water.

(iv) To standardise methods to be followed in collection and analysis of the hydrometeorological data.

(v) To prepare river basin plans for optimum utilisation of water resources.

3. *Sediment and Water Quality Observation*

The following R & D projects are proposed to be undertaken :

(i) River Sediment Studies

(a) Standardisation of sediment sampling equipment for measurement of suspende load in rivers and streams.

(b) Development of bed-load measurement techniques.

(c) Evaluation of total erosion in the country based upto the river sediment studies.

(d) Effect of soil conservation measures on the sediment yield of watersheds with specific reference to sub-catchment.

(e) Evaluation of total erosion in the country based upon the river sediment studies.

(f) Estimation of total sediment passing from different rivers into the sea.

(ii) Reservoir sedimentation studies.

(a) Measurement for density of deposited materials in reservoirs.

(b) Pattern of sediment deposition in the reservoirs of different types and sizes.

(c) Role of density currents in reservoir sedimentation.

(iii) Quality of river and reservoir waters.

(a) Pollution of water in reservoirs as a result of storage.

(b) Chemical investigation of river water for irrigation, domestic purposes, industries and fish culture.

(c) Estimation of toxic and trace elements in polluted river-waters.

(d) Effect of thermal stratification and chemical composition of water on the formation of density currents in reservoirs.

(e) Salinity of water in tidal reaches.

An outline of the works and proposed set ups to cater for the implementation of the envisaged schemes are as follows :—

A. Central Research Station

This Organisation will be a part of the Central Water and Power Commission. It will initiate research on the proposals, collect and analyse data besides supervising the work of the Regional Centres and Divisional Laboratories.

B. Regional Research Centres

Three Regional Research Centres are proposed to be set up under the Central Research Station in different zones of the country. These will organise research and development activities. with special reference to the zonal problems arising due to topography, geography and geology in the fields of sediment and water quality. The Regional Centres will also supervise and coordinate the work of different Divisional Laboratories responsible for collection and analysis of sediment and river water samples from different sites in the country.

C. Divisional Laboratories

There will be 25 Divisional Laboratories for collection and analysis of sediment and water samples from 800 sites. Each laboratory will cater for 32 sites. These will be basically responsible for analysis of samples collected from the sites, their coordination and compilation.

D. Field Laboratories

These will be set up for each of the 800 sites as an adjunct to the discharge sites. Each of these will be manned by one laboratory assistant who will work under the technical guidance of one research assistant of Divisional Laboratory. The job shall consist of daily collection of silt samples and monthly collection of water samples. As these works will be conducted along with discharge observations, existing facilities at discharge sites such as boat, launch and/or trolley arrangements etc. will be utilised.

E. Reservoir Studies

These will be done by independent units specially created for the selected reservoirs. Besides the inflow and outflow methods, yearly echo-sounding surveys for the whole of reservoir are also proposed to be conducted.

During the long term plan, the number of sites for the collection of data will be increased to 2100 and the number of Divisional Laboratories to 66. Similarly, reservoir sedimentation studies will also be extended to 40 reservoirs which will include all the major reservoirs and some important medium reservoirs.

(4) *Aquifer identification and sub-surface water level logging :*

The analysis of ground water availability and conjunctive ground water and surface water use, can generally be divided into two broad categories. These are:—

(i) The identification of the aquifer parameters and subsurface water level logging, and

(ii) The economic management of the aquifers in conjunction with surface waters.

The aquifer parameters of the ground water body which must be identified, are the storage co-efficient, the transistibility, and the boundary configuration of aquifer as also their hydrologic evaluation in terms of quantitative parameters. Knowledge must also be obtained on factors, such as the rate of natural replenishment of the ground water, the patterns and velocities of ground water flow, chemical quality of water, and changes in water levels that occur as a result of the natural pattern of ground water movement and pumping from wells.

Similarly concentrated research on the methodology and instruments for collection of data and carrying out investigations is *sine qua non* for the success of the programme.

The importance of these investigations cannot be over emphasised, as on these investigations depends all the water resources assessment and planning for its optimum utilisation. Investigations and studies on variations in ground water levels for quantitative and qualitative variations, due to pumping and natural and artificial recharge etc. are a constant feature and will be required to be carried out on a permanent basis. However, for data collection and investigations for assessment of country's ground water and surface water resources and information about hydrogeological formations and for water balance studies in the different basins of the country a time bound programme is a must. The bulk of this work should be completed by the end of Fifth Plan.

. *Hydrometry* :

The following aspects have been identified in the sector :—

(a) IMPROVEMENT IN METHODOLOGY :—

(i) Dilution methods for measurement of discharge in turbulant and hilly streams Study of chemical, radio-isotopes and tracer techniques;

(ii) Adoption of moving boat method for discharge observations in large streams and in floods;

(iii) Development of techniques for discharge measurement in hilly area and flashy streams from banks such as using cableways;

(iv) Study of the use of ultrasonic and other pressure transducer techniques for discharge measurement,

(v) Study of the method of measurement of discharge using aerial photography; and

(vi) Study of discharge characteristics of notches, weirs and flumes and other hydraulic structures.

(b) DEVELOPMENTS IN INSTRUMENTATION

(i) Instrumentation for measurement of high velocity (say above 3.5 m/s), such as current meters, deflector type indicators optical current meters, pressure transducers;

(ii) Instrumentation for measurement of low velocity (say less than 0.3 m/s), such as miniature current meters of cup type and propeller type;

(iii) Component current meters and direction reading current meters;

(iv) Echo-sounders and radio-logs with ranges for—river gauging ; reservoirs and local depth observations near structures with narrow cone echo-sounders;

(v) Distance measuring devices such as tellurometers and bank distance sounders etc.

(vi) Crest stage gauges and pneumatic gauges like bubble gauges and improvement in float gauge recorders for measurement of stage;

(vii) Telemetering and recording of hydro-metric data;

(viii) Recording and direction finding current meters for observations in tidal waterways; and

(ix) Study of other equipment used for stream gauging with a view to evolving standards wherever not available and suggesting improvements, like-boats powered or manually operated; sounding lines; conductor core cable; winches capable of manoeuvering and registering horizontal and vertical movements; cableways and cradles; telescopic and swivelling jibs for suspending stream gauging equipment away from the boat at the required distance.

It may be noted that the lack of availability of these equipment which have to be imported, rms the bottleneck for making accurate observations in a range of flow conditions met with.

(c) EXTENSION OF EXISTING FACILITIES

At present, there is only one well equipped station at CWPRS, Poona for the calibration the current meters, to cater for the whole country and therefore, it is over-loaded. Further, even in this station, there is no adequate facility for calibrating high velocities in the range of 3.5 to 8 m/s. Therefore,

- (i) there should be at least 5 regional rating tanks besides the one at CWPRS Poona, one of them should be at Delhi ; and
- (ii) Development of rating tank facilities to calibrate current meters for high velocities (beyond 3.5 to 8 m/s).

6. *Computerisation, mathematical modelling and simulation*

In this field, a need exists to develop computer programmes to tackle the following problems:

- (a) Preliminary Analysis
  - (i) Compilation, storage and retrieval of data.
  - (ii) Editing, verification and interpolation of missing data.
- (b) Statistical Analysis
  - (i) Estimating mean, standard deviation, maxima, minima and other statistical parameters.
  - (ii) Frequency analysis and fitting distributions.
  - (iii) Regression and other multivariate analysis.
  - (iv) Time series analysis, etc.
- (c) Hydrological Analysis
  - (i) Programmes of hydrologic simulation of the river basin, incorporating sub routines for the several components of the hydrologic cycle, to estimate the yield from the basin on the basis of extensive precipitation and limited runoff data,
  - (ii) A comprehensive programme for estimation of floods from precipitation data routing them through reservoirs, rivers flood control works, etc., with economi evaluation.
  - (iii) A programme for simulating wells, well fields etc. and including natural, induced and artificial recharge and salt water intrusion.
- (d) Hydraulics
  - (i) Steady and unsteady flow through open channels and conduits.
  - (ii) Flow through porous media with particular reference to earth dams, barrages channels, drains, etc.
  - (iii) Overland flow.
  - (iv) Flow through unsaturated porous media, etc.
- (e) Structures
  - (i) Storage structures
  - (ii) Diversion structures
  - (iii) Distribution systems

(iv) Cross-drainage structures

(v) Power Houses

(vi) Other structures

(f) Water Quality

When pertinent, water quality to be included in the programmes.

(g) Systems Analysis and Design

Single and multiple purpose systems for surface and/or ground water use are to be designed using specified objectives and subject to various constraints. The models for their analysis include deterministic or stochastic (linear, non-linear or dynamic) programming models and simulation models.

7. *Satellite and Remote Sensors*

Some of the important projects in the sector are described here :—

(a) Sediment studies in the Bhakra Dam and Nizamsagar Catchments.

The primary objective of the study/investigation would be to properly plan and carry out systematic reservoir sedimentation surveys, by known methods with the added advantageous use of remote sensing techniques. This is to evolve a plan of survey, to prepare maps with the help of aerial photographs and other remote sensors to delineate areas where severe erosion is occurring and areas with other categories and degrees of erosion and channels likely to carry the major sediment yield ; to carry out soil surveys, surveys of sources of sediments including geomorphic sources, land use sources and geological rock type and structural sources etc. The geological and soil information about a particular area would give some idea about the erodibility of the areas and thus help in estimating the erosion possibilities and sediment yield.

Further, the object of the study would be to evaluate the terrain for topography slope details and identification of nature and occurrence of different forms of sediment deposits and to collect data from natural streams for evolving a basis for determination of total sediment load and transportation for selected watersheds, to develop estimate prediction equations for sediment yield with the help of remote sensors coupled by ground sampling at key spots. Another study would be to study the geological source of silts in rivers, canals and reservoirs. All these are urgently needed for soil conservation programmes.

Study of pilot areas for feasibility of water harvesting and potential therein by Remote Sensing Techniques.

(i) Indo-Gangetic Alluvial Tracts of U.P.

(ii) Development of some catchment (Irrigation Works)

(iii) Hard Rock areas of Andhra Pradesh and Mysore.

The primary objective and importance of the study would be to develop remote sensing techniques specially using black and white and thermal infra-red imagery, with pilot project areas for a rapid coverage of these areas to find out the feasibility of water harvesting projects and water resources potential therein. Thus it is proposed to work out a broad division of the country into areas where water resources are available, and chronic drought prone areas where supplemental resources must be utilised. Further, by working out the terrain characteristics in terms of drainag geology, topography, climatic conditions as reflected in remote sensed imagery, coupled wi ground observations, it would be possible to delineate areas where for example :—

(i) Ground-water would be available in abundance for exploitation by tubewells, b the terrain lay out suggests areas prone to or showing signs of water logging ar where canal irrigation should be minimised and tubewell irrigation increased, such large parts of the Indo-Gangetic alluvial tracts in UP, Haryana and Punjab. Suc tracts could be better evaluated geo-hydrologically by remote sensors combined wi ground checks more rapidly.

(ii) Surface irrigation works are possible, such as Sone River Valley areas; and sm irrigation works in hard rock areas of Peninsular India where water scarcity chronic. Small irrigation works would tap surface water which otherwise useles run off and in turn would improve the groundwater position in its vicinity. He again, drainage and terrain characteristics need to be evaluated, leading ultimately to water balance assessment of the area.

(iii) Hard-rock areas—Study of surface water, underground water resources and po bilities by remotely sensed systems coupled with ground checks.

Ultimately, the objective would be to provide a basic resources inventory for suggesti further implementation of water harvesting projects in each type of area mentioned above.

8. *Instrumentation*

The instrumentation required for measurement of general civil engineering parameters re ed to the field of harnessing of water resources can be broadly classified as:—

(i) Laboratory equipment, and

(ii) Field equipment.

The complete instrumentation required for laboratory and field use can be further s divided into the following components :—

(i) Transducers, sensors, probes etc.

(ii) Signal conditioning equipment consisting of current and voltage amplifiers, pc amplifiers, attenuators, modulators or demodulators (frequency), frequency conver power suppliers etc.

(iii) Output devices such as indicators or indicating metres, stripchart, ultra violet recor oscilloscopes, oscillographs, analog or digital recorders, magnetic tape recorders

The equipment required for laboratory studies would primarily be required by institut like the Central Water & Power Research Station, Poona, the Irrigation Research Institute, Bengal and the other regional hydraulic research Institutes functioning at present; also institu like the Physical Sciences Group of the C.S.I.R., the Indian Institute of Science, Bangalore similar organisations. The number of such laboratories and the requirement of each exi laboratory are likely to grow rapidly in keeping with the general development e of the country for river valley projects and in allied areas such as communic roads, inland navigation etc. In addition, the advent of modern technology various other fields, particularly the spillover from the space technology, is likely to bring a near revolution in the hitherto used instruments and systems. For example, the usual methods for sediment estimation consists in taking *in situ* samples and then analysing them in laboratories. It is very likely that this may be changed shortly by *in situ* sediment estimation and analysis and simultaneous analysis using ultrasonic refraction of ultrasonic rays from suspended particles. Similarly, solid state strain gauges are likely to replace the currently used bonded or unbonded strain gauges. The estimation of flow in the laboratory, at present, almost exclusively measured by current metres or devices measuring difference of pressures is likely to be augmented by transducers employing temperature difference and other advanced techniques. The employment of laser beams for measurement of velocity of flowing water in laboratory and the use of ultrasonic transducers for measurement of flow in conduits and open channels have already been successfully attempted.

The employment of advanced technology, particularly in the field of electronics and physics, would also render possible, a much more accurate estimating of measurement functions which hitherto could not be estimated accurately. This includes measurement of very small velocities of flow—say of the order of 1 cm per second or less, seepage, turbulance etc.

Another important change in the measurement technology would result from the increasing usage of computer-compatible output device, from developments in the field of fibre optics and mini-computers from the availability of very small transducers whose size and sensitivity are of great importance in geometrically and kinetically reduced water studies. For example, the increase in the speed of high speed cameras has rendered possible the study of the cavitation phenomena. Similarly development of more sensitive transducers has brought engineers and scientists closer to the determination of cavitation inception. The use of computer-compatible instruments and their increasing availability and manufacture of mini-computers in India is further likely to render possible the design and installation of semi-automatic and automatic flood forecasting systems as employed in the most advanced countries of the world.

Dams, barrages and related structures constitute the key features in the harnessing of water resources. These hydraulic structures which are national assets. no doubt receive the attention of the best and up-to-date design experience: however, when dealing with nature, there still remain areas which are either in the umbra or in the penumbra of understanding and whose correct evaluation can vastly benefit from a study of structures in operation. In addition, such study can lead to continued assurance of the safety of the structure which is of vital importance.

9. *Data processing, collation, storage and retrieval*

During the last two decades, a lot has been done towards the development of irrigation facilities to bring more and more cultivated area under irrigation but still only about one-fourth of the cultivated area has been brought under irrigation. Thus great emphasis is required to be placed on planning and development of water resources and water resources projects. Planning of any type or nature can only be undertaken on the basis of data. Hence, proper collation, storage and retrieval of data in the water resources sector assumes great importance.

The chief gaps and discrepancies in the current data status have been found to be :—

(i) Lack of timeliness

(ii) Lack of consistency in seemingly same sets of data produced by different agencies

(iii) Presence of a large element of derived and subjective information with varying magnitude

(iv) Non-availability of the possible estimates of error in certain set of data series and

(v) Lack of standards in concepts and definitions.

Since at present there is no coordination. it has not been possible to reconcile the data so collected. Moreover there has not been any single agency which could go into the needs of the data utilisation of the available water resources of the country. The sub-committee has, therefore. suggested the setting up of National Water Data Centre in the Statistics Directorate of CW&PC which will coordinate activities of the various organisations assisting in the planning of water resources. The National Water Data Centre will also serve as a library where data on water resources sector are collected, stored and processed by most scientific and modern methods and tools. The setting up of small cells also has been recommended by the sub-committee.

B. UTILISATION SUB-SECTOR :—

10. *Hydraulics, Hydraulic Structures*

(a) Study of open channel plan including sediment transport.

The study of open channel behaviour on models and prototype is envisaged in this programme. This is relevant to rational design of channels, behaviour of rivers for training and control. The objectives of the research will be as follows:—

(i) Analysis of alluvial channel data to evolve rational design procedures.

(ii) Correlation between tractive forces and engineering properties of bad materials.

(iii) Investigation of shear distribution in channels.

(iv) Development of new methods for sediment exclusion in hydraulic structures.

(v) Simulation of sediment movement to scale in models.

(b) Development of model and experimental methods of analysis of structures.

The model analysis of structures and the use of experimental techniques are assuming increasing importance at the present time. These techniques can lead to economical and safe designs which can be arrived at in a very short time. Good sites for construction of dams and allied structures are nearly exhausted and the new structures will have to be constructed under difficult site conditions. This will require the evolution of designs which have no precedence and therefore, it will be necessary to take the aid of the experimental procedures.

11. *Engineering Geology, Geohydrology, Geophysics, Geochemistry, Seismology.*

In this sector some of the important projects identified are given below :—

(a) Studies of Geotechnical problems of National Importance

The object is:

(i) To create one or two centres of national importance is Geotechnical Engineering.

(ii) To prepare an inventory of Research and Development in Geotechnical Engineering.

(iii) To make available the experience and knowledge gained in complex Geotechnica problems which are present in one project or another.

(iv) To identify and undertake research for the future and take steps to fill gaps in knowledge.

(b) Engineering seismological and earthquake engineering studies in connection with design and development and execution of river valley projects and allied research

Importance of Engineering Seismological and Earthquake Engineering studies in the design, development and execution of River Valley Projects need hardly be stressed. Collection and utilisation of basic data pertaining to the design and execution of river valley projects in seismically active regions of the country is a stupendous work. CW&PRS and the School of Earthquake Engineering, Roorkee, has been doing this work in a modest way with the available talent and equipments with them. It is envisaged to extend the field of this activity to many new project sites in the country where similar data are required to be collected.

12. *Agriculture, soil water plant research, irrigation water management and drainage*

The R&D programmes may be broken up for (i) agriculture, soil plant water research and water management, which are essentially meant for improving the status of knowledge and knowhow in irrigated agriculture by better utilisation of existing water resources in these spheres. (ii) drainage for effecting soil amendments with a view to reclaiming waterlogged and/or saline and alkaline lands as also preventing the deterioration of cultivable lands, thus preserving the level of cultivation in land at present cultivable/and also bringing such areas under cultivation which are uncultivable.

13. *Material, soil and concrete*

The field of study for soils are as below:—

(a) Sampling of soils

(i) A technique of sampling of undisturbed soil has to be developed for the soils which have small percentage of gravel or kankar.

(ii) Sampling technique for obtaining undisturbed samples of gravelly soils.

(b) Shear strength

(i) Determination of shear properties of :

(1) Clayey soil having gravel in different percentages and studying the effect of saturation of such soils;

(2) Silty soil with different percentage of gravel and effect of saturation.

(3) Black cotton soils.

(4) Marine clays.

(5) Residual soils.

(6) Glacial deposits.

(ii) Connecting shear properties with soil gradation.

(iii) Strength variation along failure surface in clays.

(iv) Shear strength under impact loads.

(v) Shear strength under cyclic loads.

(vi) Shear strength under high stresses.

(c) Compaction and consolidation characteristics

(i) Determination of compaction and consolidation characteristics of :

(1) Gravelly soils ;

(2) Black cotton soils ;

(3) Fissured clays ;

(ii) Effect of different modes of compaction and variation of moisture content on density, pore, pressure and permeability.

(iii) Correlation of soil modulus at field density with that at proctor.

(iv) Means of counteracting high moisture content after rains.

(v) Acceleration of consolidation in clayey soil through the use of sand drains.

(d) Swelling characteristics

Black cotton soil.

(e) Seepage studies

(i) Permeability of soils of different particles gradation ;

(ii) Effect on permeability of clay or silt due to the presence of different percentage of gravel;

(iii) Criteria for inter-penetration of filter ;

(iv) Critical gradients for cohesive soils ;

(v) Critical gradient for cohesive soils with different percentage of gravels.

(f) Liquefaction of sands

(i) Determination of critical void ratio and grain size, for liquefaction of sands under shock loads;

(ii) Determining effect of loading of sands on its susceptibility to liquefaction ;

(iii) Determination of effect of subsequent shocks after liquefying shocks are over.

(g) Structural problems

(i) Effect of presence of lime lumps in soil for hearting or shoulders.

(ii) Use of silty soils in clay cores.

(iii) Rationalisation of design criteria for embankment stability for static and dynamic conditions.

(iv) Study of progressive development of stresses in an earth dam as it is raised.

(v) Effect of sudden pronounced foundation irregularities on the behaviour of earth dams ;

(vi) Settlement of dam foundation under dam load and reaction thereof on the dam.

(vii) Internal load transfers in an earth dam consequent to settlement during and after con truction.

(viii) Determination of bearing capacity of foundations.

(h) Rock

The fields of study identified are :

(i) *Classification of Rocks*

(1) Rock classification by hardness test.

(2) Interrelationship of petrographic, physical and chemical properties.

(ii) *Sampling and Insitu Testing Techniques*

(1) Sampling of undisturbed shear zone material for the case of thin shear zones.

(2) Testing techniques of insitu strength of rocks in various directions to the joint bands.

(3) Testing techniques of shear strength of rock mass along shear zones or weak rock bands.

(iii) *Structural behaviour*

(1) Establishing methods of observing long term rock movements and change of strain in rock masses, specially under the effect of reservoir loads and loading due to dams and analysis thereof.

(2) Stability of rock masses, specially during earthquake.

(3) Permissible strength of rocks in different directions w.r.t. joining pattern in rock mass.

(4) Determination of rock loads on tunnel ribs and lining .

(5) Readjustment of rock stresses due to tunnel boring.

(iv) *Treatment of rock masses*

(1) Techniques for improving rock for water tightness as well as deformation under load.

(2) Measures for prevention of slides.

(3) Development of materials other than rock for use in rip-rap on dam and protection of flood embankments, etc. for use in areas where rock is not easily met.

(v) *Miscellaneous*

(1) Measures for permitting overflew on earth and rockfill dams.

(2) Effect of curving the axis of rockfill dams on the internal load distribution.

(i) Concrete

(i) *Mix Design*

(1) Developing concrete to withstand erosion by boulders.

(2) Use of marine sands and aggregates in concrete.

(3) Developing weather resistant concrete for high altitude work.

(4) Investigation on separation of second design concrete in block out and evolving better mixes for such use.

(ii) *Repairs to concrete*

(1) Treatment of cracks in concrete.

(2) Measurement of crack depths without destroying concrete.

(3) Developing repair techniques for damaged concrete.

(iii) *Admixtures*

(1) Study of pozzolona for concrete and reinforced concrete.

(2) Admixtures for quick setting and no shrinkage.

14. *Water pollution control and monitoring water conservation, reuse research*

Short term and Long term Research and Development Programmes

While giving consideration to investigating problems of pollution the following 3 steps become apparent:

(a) Recognition and definition of the problem with respect to the type of pollution, its constituents and their effects on human, animal or plant life.

(b) Determination of the practical limits of these contaminants which will permit freedom from concern for human, animal or plant life.

(c) Development of a method of treatment so as to control the contaminants to a safe and acceptable level of determination of disposal methods in water and air, utilising the knowledge of fluid mechanics and model engineering to arrest or constrain pollution levels to a safe concentration.

Besides investigating the prevailing problems of pollution it is also necessary to prepare for those which may arise in the future. Pollution is a growing and often a hidden problem and it is necessary to prepare for events to come. It is, therefore, essential to assemble "baseline" information on still unpolluted parts of the environment against which we can measure the effects of pollution. Subtle changes can be recognised only by means of a long series of painstaking observations where exploitation is planned or is proceeding.

The problem of thermal pollution has assumed importance in view of the tremendous growth in the consumption of electrical energy and in the increasing size of thermal power stations, both of the fossil fuel and nuclear fuel types.

15. *Sedimentation, watershed management*

(a) *Reservoir Sedimentation*

The capacity surveys have been conducted only in 11 major reservoirs and the rest are still un-surveyed. The guidelines fixed by the CBI&P for frequency of conducting capacity surveys are not being adhered to even in these reservoirs. Some of the reservoirs were surveyed 8—10 years ago.

For conducting capacity surveys by echo-sounding method considered to be the most accurate at present, it is essential to lay out contour ranges at a fixed interval at the time of construction of the project itself as it becomes cumbersome and difficult to lay out range lines after the completion of the reservoir.

(b) *Suspended load data of rivers/streams*

There should be documentation of gauge and discharge, silt and rainfall data for all the existing and proposed sites in the country. It will bring uniformity in the collection and collation; assess their deficiency and make corrections wherever required. The National Water Data Bank will be the ideal place where the entire available data will be pooled. It will be a repository of technical data for reference and use for various purposes in the country.

For proper interpretation of sediment data, we require meteorological and hydrological data of the catchment *i.e.* rainfall intensity & frequency, run-off, evaporation and transpiration losses and infiltration rates for various types of soils. Therefore, we should have evenly distributed automatic raingauges for at least every 250 sq. miles of plains and 50 sq. miles of hill areas. At present, the Indian Meteorological Department (IMD) is maintaining 10 per cent of the total rainguages in the catchment areas of river valley projects.

(c) *Watershed management*

The first step in planning the watershed management is to have an inventory of basic data. This will include collection of meteorological, hydrological soil and landuse data (including slopes, degree of erosion, extent of eroded area etc.) and the economic and social conditions of the catchment. Such information on the above aspect will help in scientific planning and execution of the soil conservation measures.

Soil surveys are considered as a basic investment for improving Soil and Land Development and have to be accorded the highest priority. No proper nation wide surveys have been carried out so far to obtain an accurate idea of soil resources and to locate and identify the areas which need priority attention. At the present rate, it will take about 3/4th of a century to survey the entire country. The nation cannot afford to wait for such a long time. The only alternative to cut short the time lag is the use of aerial photography and its interpretation. This, however, will not replace the soil surveys. The aerial photo-interpretation unit at Indian Agricultural Research Institute should be strengthened to meet the requirements of the nation in respect of river valley projects and units should also be opened in each state for meeting their requirements.

(d) *Shifting cultivation*

Stopping or regulation of shifting cultivation is a socio-economic problem and can be tackled through the programme of resettlement of oustees under proper legislative measures. Areas suitable for permanent agriculture under the process of shifting cultivation should be assigned to agriculture and allotted to farmers whereas the rest of the areas vulnerable to this abuse should be brought under permanent vegetative cover.

Cultivation on slopes exceeding 30 per cent and breaking of new land for agriculture should be stopped and all critical areas including scattered bits of waste lands, known as 'khas mahal' in the eastern region should be transferred to Forest Department for afforestation. These steps will go a long way in solving the problem.

16. *Hydro-mechanical equipment*

Some of the important projects are :—

(a) Design, Development of large valves for control works

Even though Howel Bunger valves and Hollow Jet valves are very useful control equipments to regulate flow, through outlets in Dams, no headway, worth mentioning, has so far been made in this field. The designs of these valves have to be developed in the country taking into consideration the materials and the workshop facilities available within the country. In addition, the conflicting requirements arising out of hydraulic characteristics and mechanical strength considerations, due to high heads and the consequent high velocity flows have to be matched for a safe and efficient design. Evidently problems of cavitation and vibration have also to be studied in hydro-elastic models. These valves offer a decidedly improved performance as compared to the conventional high head gates. This programme would also cover the design of butterfly and spherical valves for penstocks.

Presently water pumps are designed and manufactured entirely in the private sector. In the Public Sector, Bharat Pumps and Compressors is being set up, although it will take a few years for its products to come to the market. In the Private Sector none of the manufacturer have any comprehensive R&D facilities for evolution or development of hydraulic designs of pumps. Large scale pumps are not at all attempted in the Private Sector for various reasons such as non-repetitive nature of design and production, very large initial capital outlay and absence of systematic data on mechanical and hydraulic designs. Normally above a discharge of 1.5 m.cu./sec. or 500 H.P. power input is deemed to be a large pump. Efficient design of water pumps (in particular applications) is important as improper design will be greatly wasteful of energy, also connoting high cost of losses through outage. The importance of R&D on water pumps would aim at making available to all the manufacturers, facilities at viable costs for and results of systematic research investigations on designs of impellers and auxillary units.

The main types of pumps covered by general items of water pumps are centrifugal pumps and axial flow pumps and the mixed-flow pumps.

The centrifugal pump field is fairly well known but little advance has been made in the domain of axial flow pumps and mixed flow pumps which are mostly required for lift irrigation schemes. There are other types of special pumps, for example, the submersible pump which as the name implies operates under fully submerged conditions as a complete unit i.e. the electrical motor and the pump coupled together. For large scale dewatering and under water construction submersible pump have their own importance . Dredge pump is yet another type of special pump required for dredging mostly navigation channels in ports and harbours, surges and rivers. For desilting large water and power channels and river training works, dredge pumps, are frequently utilised. The main objectives of R&D are:

(i) Development/standardisation of impeller designs for specified ranges including hydraulic passages.

(ii) Survey of requirements for selecting typical designs for development.

(iii) Development of designs for following specific auxillary equipment.

(1) Pressure reducers, check valves.

(2) Surge suppressors.

(3) Pneumatic vessels for water hammer control.

(4) Special units such as bends and Y's of pipe lines.

(5) Strainers.

The bridging up of the gaps narrated above requires (i) development of designs of the machined items; (ii) testing at models and proto-type levels; (iii) basic research in respect of some elements. This work is primarily to be initiated by the manufacturing agencies. The design development work can be done by them and the necessary testing of models etc. required in this connection should be carried out by C.W. & P.R.S. laboratories. Basic research required can also be undertaken by C.W. & P.R.S.

GROUND WATER

Some of the important projects identified in this subsector are given below.

17. *Hydrogeology*

(a) "Study of hydraulics of open wells/tubewells leading to the theory of pump test for evaluation of hydraulic characteristics of a quifers specially in the hard rock areas."

Systematic geohydrological surveys carried out over extensive areas covered by hard rocks have indicated that groundwater occurs in the weathered zone, the thickness of which extends to a maximum of 20 m.b.g.l. as also in the jointed and fractured zones that may occur below weathered portion. The effective thickness of the jointed and the fractured portion may be 8-10 m below the weathered zone. Groundwater mostly occurs under water table conditions in these zones. Nevertheless, instances of occurrance of groundwater under pressure conditions have also come to notice at a number of places. The zone of weathering has been found to be very erratic both vertically and laterally, thus making it difficult to understand the hydraulics of such formations without proper and detailed studies.

The scheme envisages demarcating different water bearing zones in hard rock areas, their disposition with respect to one another and the hydraulic characteristics individually or collectively. All this data so collected would, not only, throw light on the groundwater potentialities of the water bearing zones in hard rocks, but also bring out the economics of withdrawal of groundwater. This will help in the problem of spacing between wells in this area. All these aspects of studies would eventually lead to the basin-wise management of groundwater. The following programme of work is envisaged:

(i) Systematic geohydrological survey over an area of about 500 sq. Km. and drilling of 100 boreholes (approximately 1 borehole for every 5 sq. km.).

(ii) Geophysical survey both by resistivity and hammer seismic methods, to have an idea about the thickness of the zone of weathering and fractured zone below it.

(iii) Drilling of pilot borehole of about 10 cm. diameter through the weathered and the fractured zone till the massive fresh rock is met with.

(iv) Verification of the lithological logs obtained at the time of drilling with the geophysical data.

(v) Drilling of the second borehole close to the first one to pierce the weathered zone.

(vi) Conducting an yield test with a small capacity pump for a discharge of 6,750 litres (1500 gallons) per hour.

A small capacity pump is particularly required here in order to control the discharge so that the aquifer is strained and water is drawn from the aquifer for long periods to create a zone of depression. If a higher capacity pump (with higher horse power) is used the borewell may get dried soon without creating stable pumping conditions in the aquifer.

(vii) Evolve suitable formula or a workable method for obtaining aquifer parameters on the basis of the above test.

(viii) Ream the pilot borehole to a bigger diameter and seal off the weathered portion.

(ix) Drilling through the fractured and jointed portions from both of these reamed boreholes. This individual testing may give an indication, if the water in the weathered and fractured zone is under confined conditions.

(x) Conduct a test on this borehole in order to find out if any hydraulic characteristics could be worked out.

(xi) Conduct a cumulative test on both the aquifers.

(xii) Well depths and economics.

(xiii) Analog model studies.

(b) *Studies on the possibilities of Artificial Recharge of Groundwater in the semi-arid to arid tracts of India (Eastern Rajasthan and Delhi in the first phase)*

The aquifers present in the area are limited both as regards number and capacity and where a suitable water source, but with a scanty and for the future insufficient capacity, lies within a consumption area, artificial infiltration can make up the deficiency to the required amount. Besides increasing available groundwater supplied for use throughout the year the data available will also help in problems like reducing over draft and surface run off. The basic principle which makes possible the utilisation of a proposed infiltration area is the improvement taking place during the passage of water through the ground. Unfortunately very little is known of the essential details of this process and the subject calls for detailed investigations. Artificial replenishment will also help in preventing water losses resulting from evaporation. The methods used will provide information regarding physical and chemical changes which take place during filtration of water through the aquifers. Biological effects, temperature of water, the chlorine content etc. are some of the other vital details which will also be available. Major industrial complexes are coming up very fast around Khetri, Jaipur and Delhi. The disposal of industrial waste will be a problem. If this waste can be used for replenishment in needy areas, it will solve many of the scarcity problems. The water logged areas in Punjab can easily be pumped off to replenishment basins further south.

The plan of work consists of :

(i) Preparation of water budget of the area.

(ii) Evaluation of water resources which can be used for recharge.

(iii) Geohydrological investigations for the aquifers which will be recharged.

(iv) Application of the established recharge methods.

(v) Search for the most suitable and economic recharge method.

(vi) Extension of observations made in the project area to other parts of the country.

18. *Groundwater Geophysics*

(a) *Development of 3 types of Electronic Insruments that will be useful in groundwater Exploration*

(i) A multi/channel seismic refraction timer employing signal enhancement techniques.

(ii) A water level recorder (particularly for tubewells).

(iii) An induced polarization equipment.

In the exploration for groundwater the two most frequently employed methods are electric resistivity (AC/DC) and seismic refraction. The instruments that are presently available in the country, need further development so that data can be collected quickly and accurately. Any marked development in the tools of exploration for groundwater will go a long way in assessing the groundwater resources of the country.

At present, a DC earth resistivity potentiometer and a single channel refraction seismic timer with meter indication are being manufactured by the B.P.U. of N.G.R.I. The demand for these instruments is quite high. The presently available water level recorders are fit for use in open wells or cased wells that are not being pumped. At present I.P. instruments are not being made in the country.

The instruments that are proposed to be designed will have improvement over the presently available types.

The estimated duration for completion of design, construction and testing of seismic timer is 3 years. And in the fourth-year, the prototype will be handed over to the Pilot Plant/B.P.U. for manufacture.

Work on the other two items *viz.* water level recorder and I.P. will be taken up after the design, construction and testing of seismic timer is completed (*i.e.* after 3 years). The design and construction of these two items will be taken up concurrently but with a priority for water level recorder. The design and construction of these items are expected to be completed in 3 years. Perhaps it will be possible to complete work on water level recorder earlier.

(b) *Development and adaptation of geophysical methodologies as an intrinsic component of integrated geoinvestigation in geohydrological problems calling for a coordinated effort—simulation of aquifers*

The currently used geophysical methods are not conclusive in the indication of the presence of aquifers. Most of the methods utilise the electrical resistive properties of water. The proposed research will concentrate on the study of dielectric properties of water and attempt to evolve a suitable pulse generator for utilisation in simulation of aquifers electrically.

A new approach for the design of Electronic Analog Computers for simulating aquifers was developed by E. P. Kumaraswamy at Irrigation Research Station, Poondi in the year 1969. A novel method of pumping test called the dipole pumping test has been evolved. Irrigation Research Station, Poondi has already done pioneering work in this direction and facilities are available at Poondi for undertaking research in this area.

The dielectric properties of water as dependant on velocities of flow will be studied in detail. Correlation between pulse automation/distortion and the presence of aquifers will be derived both in the laboratory and field tests. An electrical dipole test will be evolved for use in prediction in the field.

(c) *Exploration and Management Studies of Groundwater Resources*

It has been estimated that the total utilisation of groundwater for irrigation, industrial and domestic use, in 1971-72, has been 10.5 million hectare meters. From the data available for 1968-69, it has been projected that the total area to be irrigated in India from groundwater resources at the end of 1973-74 will be 17.8 million hectares and by 1978-79 the figure will rise to 22.7 million hectares. The volume of water required for the irrigational purpose is estimated to be 11.25 million hectare meters and 14.35 million hectare meters respectively. Taking into consideration the contributions from rainfall, seepage from rivers, canals and other surface water sources, and the losses due to evapotranspiration and sub-surface drainage, the net annual groundwater recharge is estimated to be 26.7 million hectare meters. The property of replenishment makes the exploration and exploitation of groundwater a dynamic process.

In the plan of work the following are proposed to be undertaken:

1. Three areas of about 8,000 sq. km. each will be selected in three regions of the Andhra Pradesh *viz.* Coastal regions (sedimentaries), Rayalseema (Meta-sediments) and Telengana (granites). Through study of aerial photographs, the prominent features will be identified as regards drainage pattern, lithology and structure and the area will be demarcated into different blocks on this basis.
2. Geological reconnaissance survey of the areas to investigate the water-bearing properties of formations will be carried out.
3. Geophysical surveys will be made on regional scale to locate broad zones of groundwater. Detailed localised geophysical investigations will pin-point well locations. The geophysical methods to be employed will include electrical resistivity sounding, electrical resistivity profiling, total magnetic field intensity measurements and seismic refraction time studies. The interpretation of data will demarcate broad zones of potential groundwater reserves and also predict the location, depth, thickness and water quality of the aquifers.
4. Hydrogeological studies will include:
   - (i) A compilation of the well-inventories;
   - (ii) Drilling of about 300 test wells in three areas;
   - (iii) Analysis of the parameters like precipitation, run-off, evapotranspiration, infiltration, and their correlation with the groundwater reserves;
   - (iv) Analysis of geological and geophysical logs of the existing and new boreholes and lithological correlation;
   - (v) Analysis and assessment of water quality;
   - (vi) Measurement of physical properties of rock samples like porosity, permeability, grain-size, mineral contents, electrical resistivity etc.;
   - (vii) Pump tests for estimating storage capacity and yield of aquifers;
   - (viii) Collection of water samples and measurement of tritium and radio-carbon contents for chronometric studies and measurement on other tracer elements for movement recharge and cyclic phenomena studies;
   - (ix) Selection of realistic models based on the range of aquifer parameters, obtained in the project and other available data, for studying both saturated and unsaturated systems through:
     - (a) mathematical analysis of flow problems in homogeneous and anisotropic ground sections with relevant boundary conditions;

(b) statistical investigations employing such techniques as periodograms, auto-correlations, correlogram, power spectrum, multivariate and time-series analysis, Markov chain and Monte-Carlo methods; and

(c) electrical analogues and computer simulation of aquifers.

5. Trainig of the personnel will be organised at the N.G.R.I., Osmania University and University of Roorkee.

19. *Groundwater hydrology*

(a) *Determination of recharge for an area*

Most acute water shortage have occurred in places of apparent abundance. In shortage areas, the key to minimising the impact of drought would be to provide the capacity to store water during the period of abundance. The extremely intricate aquifer systems below the ground level present the need for study in depth, of its capabilities in these directions. The management of these aquifers in relation to need for a particular area would have to be controlled by having a very low draw down storage during peak consumption periods. This could be replenished by recharge during the periods of surplus surface water. Such management to provide a seasonal and cyclic water supply control would ensure the needs of water as well as reduce the waste of flood water.

For condition of natural recharge, it would, therefore, be necessary to examine in detail,

(i) the penetration of soils of hard rock surface,

(ii) the mechanism of downward movement of water through partially saturated medium,

(iii) accretion of incoming water to zone of saturation.

For artificial recharge systems, it is necessary to examine,

(i) the capture and saving of water for future requirements,

(ii) alleviate flooding,

(iii) improve water quality,

(iv) store cooling water,

(v) build-up in some coastal aquifers fresh water barriers to reduce salt water encroachment.

(b) *Evaluation of surface and groundwater reservoir storages*

Although considerable advances have been made in the fields of design, practice and operation to manage surface storage reservoirs, there is still a great deal to be done for groundwater storage. The observations made are:—

(i) many of the aquifer systems especially those of coastal plains and some mid continent systems can hold far more water than most surface water reservoirs,

(ii) sub-surface storage does not loose water through evaporation,

(iii) extensive aquifers are in a sense pipelines of vast proportions that not only store water but also transmit and distribute it,

(iv) water in aquifers is comparatively protected from different kinds of contamination.

(v) even aquifers containing salty water could be used to store fresh water for later recovery.

(c) *Surface clogging for artificial recharge:*

In artificial recharge, problems posed by clogging of the recharge surface is a serious difficulty for designing a good and viable operational system. This provides an extensive area of work for experiments on small-scale within the laboratory as well as in the field where the feasiblity of physical, chemical and biological methods for inhibiting clogging could be evolved and evaluated. It would go a long way to bring artificial recharge as a practical method in engineering design.

(d) *Velocity measurements of groundwater* :

Preliminary laboratory studies have shown that the dielectric properties of flowing water indicate the possibility to develop a methodology for locating and tracking veins of under ground water. If the system could be developed to yield consistent and dependable results. it would be helpful for the location and development of wells particularly in difficult hard rock areas.

(e) *Governing parameters of ground water regime* :

Although the main parameters for ground water are generally indicated their inter-related behaviour for specific ground water regimes would need a very careful study in relation to (i) ground water levels (ii) ground water contours and their seasonal fluctuations, so as to be able to asses the availability and behaviour of the ground water body as a whole.

(f) *Ground water velocity measurements* :

An essential requirement has been felt for the need to have reliable velocity measuring devices for the range of about I meter/day at depths upto 200 meters. The use of tracers, improved velocity meters, and remote sensing devices from ground level, are areas which could be examined for development.

(g) *Delineation of significant areas* :

In regions, specially hard rock areas, the general water bearing medium presents a situation of sigularities which is not amenable to define the general pattern and therefore the delineation of areas having similarity of ground water flow regime characteristics is of great practical need for reliable design of engineering systems.

(h) *Vertical and horizontal movement patterns for recharge* :

On the basis of actual measurements of the ages of deep ground water in the Indo-Gangeti alluvium, it is felt that the horizontal movement is extremely slow, but in hard rock areas higher velocities are usually encountered. The water bearing media is likely to come across a serie of impasses which do not permit the necessary connections to form interconnected areas o flow. This limits large-scale horizontal movement. Thus, in our country, the dominant mod of recharge is probably in the vertical direction with possible exceptions in lime-stone areas The influence of the vertical versus horizontal movement patterns for any particular area o development is therefore to be established in the design and management of ground wate systems.

(i) *Control wells grid* :

It is difficult to study each small area in terms of all details of the ground water regim As a practical measure, the establishment of suitable control wells is necessary so that the behaviour could be taken as an approximate indication of the general behaviour of the fluctuations in the areas. This data is of considerable significance in estimating the quantity available as well as the permissible draw from the area as a whole which is of vital importance in assessing the water balance of the area.

(j) *Monitoring of ground water quality* :

The quality of ground water to be free from harmful levels of contaminants is essential. This could be initiated by monitoring of ground water quality with respect to toxic ingredients and fluorides. Such studies could be started in the first instance in areas with high incidence of chemical pollution such as places of intensive application of fertilisers, pesticides, wastes from tanneries, sugar mills etc. Simultaneously these studies could also include an assessment of the beneficiary effects of adsorption by top soil.

(k) *Economic use of chemically polluted water* :

The possibility of ground and surface water having a higher incidence of chemicals from different kinds of industrial or agricultural wastes and pollution to be used directly for agricultural purposes, where such chemicals would serve as fertilisers, needs very careful study depending upon the nature of these activities in different regions. This regional index is significant. The possibility of direct divisions of such water as well as storage at surface or underground of this water is a problem for engineering design.

(l) *Simulation and computer application for ground water basins* :

The primary objective of all simulation is the prediction of the behaviour of the basin. A proper conceptual model with necessary computer system would permit to study a wide range of solutions. The system could be identified on the basis of hydraulic data, basin geometry and parameter distribution, the excitation/response relationship of model compared with field observations. This would also enable the formulation of critical water control policies. For the solution of a difficult non-linear partial differential equation, he space is replaced by a set of discretely spaced points. In addition to the digital, it is also possible to use an analog method which consists of a net work analog or the electronic analog with analog integrators. A very useful system is the use of discrete space, discrete time hybrid ype of computation particularly for the solution of non-linear field problems. The main components viz:—hydraulic potential, the total accretion of water table, due to rain-fall wells tc., aquifer transmissibility, storage co-efficient, are the main co-ordinates of representation. Above all, the development of feasible management alternatives in complicated ground water low systems is made possible where simulation by the digital analog or hybrid form becomes ndispensible. This is due to the fact that such studies enable,

(i) realistic consideration of actual flow system involved.

(ii) accurate predictive capability for evaluation of management alternatives.

(iii) economy in conducting the required measurements and predictive analysis.

m) *The problem of salt water intrusion in coastal areas* :

Over-draft of ground water by pumping in coastal regions creates serious problems of esh water contamination which affects industry, domestic usage and agriculture. The beaviour of intruded salt water in coastal aquifers under various conditions of recharge and water thdrawal needs study. The analysis of gravity wells and over pumped artesian wells are od applications. A consideration of dispersions, tidal effects, leakage and evaporation are cessary. This would help to determine the location depth and capacity of individual wells.

20. *GROUNDWATER ENGINEERING*

Ground-water engineering essentially covers the design and construction of groundwater structures (wells and tubewells) in relation to a given set up, hydrogeological and hydrological conditions, with a view to serving the desired need and the objective as minimum of cost. It also includes drilling development and other techniques as used in construction of tubewells or boring of dugwells, and the subject of water lifting appliances/pumping equipment used for raising water from dugwells and tubewells.

Areas/items for research have been identified under seven major heads which cover the field or groundwater engineering.

(a) *Dugwells in Alluvial Areas*

The following are some of the areas of study:—

(i) To study the relationship between the diameter and discharge of dugwells.

(ii) To evolve criteria about depth, draw-down and foundation design in different types of formations.

(iii) To evolve criteria about the thickness of steining.

(iv) To evolve a suitable design of previous steining for augmenting the discharge.

(b) *Dugwells in Hard Rock Areas*

In this area the following are areas of study:

(i) To study the effect of such parameters as the depth, draw down, and thickness of the weathered zone and fissures, fractures etc. on the yield of the wells.

(ii) To undertake studies for evolving criteria for lining of top portion (in soil mantle and weathered zone) of dugwells.

(iii) To evolve broad criteria regarding the comparative merits of various operations for increasing the yield.

(c) *Tubewells*

In this area the following studies have been identified:—

(i) To study the ffect of penetration and the open hole and the relative placemen of the screens in relation to the bore hole on the discharge of the tubewells.

(ii) To study the relation of yield to aquifer anistropy.

(iii) To study the economic advantages of higher operation draw-down versus othe measures like larger diameter, length or opening area of screen in improvin the discharge of well.

(iv) To study the effect of the diameter and open area of the screen and of spaci and type of slots on the headloss in the flow of water in the vicinity of the we and through the screen.

(v) To evolve suitable criteria about the permissible entrance velocity through t tubewell screen with reference to sand movement and corrosion and encrustati rates.

(vi) To evolve criteria about slot size in relation to aquifer material.

(vii) To evolve suitable criteria for gravel pack design in relation to the aquifer pack material.

(viii) To study the optimum thickness of casing pipes/screens, and optimal design of their joints.

(ix) To undertake studies for comparative evaluation of different types of screens presently in use.

(x) To undertake studies for improving the existing screens and development of new screens.

(xi) To undertake studies for improving the design of coir strainer.

(xii) To study sick/failed wells with a view to determining the causes and improving future design and rehabilitation practices.

(d) *Bore Wells*

In view of the increasing popularity of bore wells, research studies are urgently called for in the following specific directions:

(i) To study the hydraulics of bore wells in different typical formations.

(ii) To undertake studies for comparative appraisal of feasible pumping equipment for bore wells.

(iii) To undertake studies for improving irrigation performance of bore wells.

(e) *Drilling and Construction Techniques*

The following studies have been identified:—

(i) To undertake studies for improving drilling techniques including introduction of new techniques.

(ii) To undertake studies for improving metallurgy and other processes for indigenous manufacture of drilling and fishing tools.

(iii) To undertake studies for establishing satisfactory methods and tools for coring in unconsolidated formations.

(iv) To undertake studies for improving and standardising the quality of the mud and the chemical additives used in rotary drilling.

(v) To undertake studies for evolving suitable equipment for gravel feed.

(vi) To initiate studies to develop proper techniques and equipment for formation testing and isolation of formations with poor quality of water.

(vii) To undertake studies for improving development of wells.

(viii) To initiate studies for evolving proper criteria for sanitary protection of wells.

(f) *Indigenous Water Lifting Appliances*

The following specific areas are identified for further research :

(i) To undertake studies for standardizing the design of Persian wheels in relation to various lifts requirements.

(ii) To conduct studies for improving and standardizing design and construction of rope-and-bucket lifts including Kapila and circular mhots.

(iii) To undertake studies for evolving a suitable animal operated pump for lifting water from shallow tubewells.

(g) *Power Pumps*

The following critical areas are identified where most fruitful R&D work can be carried out :

(i) To undertake studies for improving the metallurgic and hydraulic design of the component parts used in the pump.

(ii) To undertake case studies for evaluating the comparative performance of various types of pumps.

(iii) To undertake studies for standardising optimum design ot pumps.

Sub-sector: EARTH SCIENCES

The basic knowledge of natural resources in the larger perspective of space and time, is extremely vital to develop our future strategies for exploration and exploitation of these resources.

While no doubt the problems relating to the ecological balance and environmental pollution are extremely important in all programs concerned with exploitation of natural resources, there are other problems relating to natural hazards, like earthquakes, floods, cyclones, volcanoes, etc. It is of course impossible to eliminate these disasters, but with increasing applications of science and technology we can possibly minimise the loss of life and property by exercising some degree of control and monitoring these disasters.

Seismology deserves more intense study not only because of its application in predicting earthquakes but also for its contribution to construction of river valley projects and prospecting for water and oil. Even today the seismic method is considered the best method for the final location of oil reserves. Seismic wave have similarly proved to be very efficient tool for probing into different depths of the earth's crust and finding correlations between distribution of mineralised zones and the detailed structure of the earth's crust and upper mantle. Intensive studies of the deformation associated with earthquakes has already shown promise for the seismologists to hopefully look forward to prediction of earthquakes. Also seismological studies contribute considerably in our understanding of the forces/movements inside the earth. Through the intensive and cooperative efforts of all countries during the IGY and the Upper Mantle Project periods, a concept has already evolved of sea-floor spreading and movement of plates which have thrown light on many important geological and tectonic problems such as mountain building and continental drift.

Geomagnetism and the immediately allied discipline of aeronomy are probably the two branches of geophysics which have benefited most from the giant strides of advance achieved in space physics during the last decade. The most outstanding conceptual advance in geomagnetism during these years has been those of the solar wind and magnetosphere. The magnetosphere which can be considered as a giant bag filled with solar plasma in active movement presents itself as an unique space laboratory where, through instrumented satellites and space probes, fundamental physical processes can be seen and studied *in situ* such as collisionless shocks, hydromagnetic waves, field-particle interactions, particle accelerations, trapping and diffusion etc. and interpreted in terms of their magnetic and electrical effects observed on the surface of earth. Interplanetary space which, till the 1950s, was generally considered as an empty void at least during periods of solar quiet, is now found to be a rather busy environment witnessing active interaction between charged particles having a wide gamut of energy ranges and electromagnetic radiation covering the entire frequency spectrum from radio wave end to the gamma ray limits. Of immediate interest to shortwave communications via the ionosphere is the profound influence of geomagnetic activity on the propagation of high frequency radio waves. Increase of solar activity followed by perturbations of the earth's magnetic field is almost always accompanied by disruption or serious dislocation of high frequency communication. Predictions of solar flare effects and magnetic storms are, therefore, extremely valuable for efficient shortwave and cable communication.

While the satellite operations for studies in geomagnetism and allied fields have been largely confined to the U.S.A. and U.S.S.R. at present, a beginning was made in our country in 1968 when the Equatorial Rocket Launching Site was commissioned at Thumba near Trivandrum (close to the magnetic equator) from where the equatorial ionosphere—in particular the electrojet—is being studied by rockets. India commands an unique position in geomagnetic research since the Colaba and Alibag magnetic observatory (now forming part of the recently started Indian Institute of Geomagnetism at Bombay), has the longest span of high quality magnetic data in the world dating back to the 1870s. India is also, among the only three countries in the world (the other two being S. America and Africa) through which passes the earth's magnetic equator, observations from which location are very much sought after by geomagneticians.

Underneath the surface of the earth lies hidden, an immense source of energy which evidences itself in the form of volcanoes, hot springs, earthquakes, etc. The source of this energy is the hot interior of the earth. Already several countries, including New Zealand, Italy. Hungary, Japan, Iceland, United States and USSR have started exploiting this energy considerable R&D inputs will be necessary in order that we are also able to make use of this energy, existing in the form of hot springs in this country. Apart from using this energy for power generation, it can be utilised for heating of houses, extraction of dissolved salts from mineral waters, desalination, tourist resorts and in processing industries.

Palaeogeophysical studies provide physical measures of the global properties in the geological past and include such disciplines as palaeomagnetism (including the study of the archaeogeomagnetic field) palaeotectonics, palaeoclimates and magnetic-stratigraphy, palaeogeodesy and palaeothermal studies. The importance of these studies lies in the constraint they provide on any model of the planetary evolution. These studies also aid in the appreciation of the structural and tectonic fabric of a landmass. Geodynamics studies, now being organised under the International Geodynamics Project, concern the dynamics of the deep interior which provide the causative forces in the evolution of crustal and sub-crustal features. These studies include the rheology and physics of the earth's interior, record of the past movements and the nature and pattern of the movements in the seismic and aseismic regions, etc., improved knowledge of which should lead to a better understanding of the global surface and interior.

The knowledge of the various physical properties of the rocks (such as magnetic, electrical, elastic, radiometric and thermal properties, density, etc.) and their variation with the changes in pressure, temperature, composition, water content, etc. is the basis of any method of geophysical exploration. The knowledge of these properties is also essential in studies pertaining to the solid earth.

In India the relevance of increased R & D endeavours in the above studies can be readily gauged from the facts that there hardly exists, at the present time, any significant concept oriented exploration for the natural resources. The details of the geologic evolution of the Indian landmass, and of the structural and tectonic fabric of the landmass, need careful examination before any such concept for the zonal mineralisation, weak (seismic) and rigid (as seismic) regions, etc. can be evolved.

Development of indigenous know-how and R&D in instrumentation is very vital for carrying out exploration work for natural resources. The sub-committee on instrumentation for earth sciences has come out with a number of projects to fill the gaps that exist in R&D in this country. These efforts will eliminate dependence on imports for geophysical instruments and seeks to make our country self-reliant in this important area.

From the above paragraph it is evident that for exploring our natural resources, especially minerals, oil, ground water and geothermal resources and also to predict the occurrences of natural hazards like earth-quakes, tides, etc. there is an urgent need for increasing our knowledge in various aspects of our earth as a whole. Some amount of R&D efforts have already been put in some of the existing geophysical institutions. With the availability of improved technology and sophisticated instruments in the advanced countries like U.S.A., Canada, U.S.S.R., our R&D effort needs to be geared up so as to absorb these technologies, improve upon it and innovate further to suit our conditions. In this context, it may be mentioned that a large number of exploration instruments are now being imported every year for undertaking ground geophysical studies for mineral exploration etc. Aerial geophysical survey are still being carried out with foreign collaboration. A few of the airborne instruments have been developed in the country which are already flight tested. Intensive R&D efforts are needed to make the country self-sufficient in the field of geophysical exploration.

While formulating the R&D plan in different areas of earth sciences the concerned subgroup took note of existing knowledge in the country vis-a-vis abroad, identified gaps in our knowledge and their economic importance in exploration and exploitation of our natural resources like minerals, water etc. The estimated total financial outlay required in this sub-sector would be about Rs. 10 crores.

A consolidated statement of the R&D proposals including the financial outlay is shown in Table 1 below:

TABLE 1

BREAK UP OF OUTLAY SECTOR-WISE

S. No.	Area of Research	No. of Projects	Financial Outlay (Rs. in crores)
1	2	3	4
1.	Seismology	18	2.62
2.	Geo-magnetism & Geo-electricity	6	2.34
3.	Geo-thermal resources	3	0.35
4.	Palaeogeophysics, Geodynamics & Physical Properties of Rocks	34	1.22
5.	Instrumentation for Earth Sciences	10	3.55
	Total :	71	10.08

The projects identified are given below

A_1 : Seismology

Project Index No.	Title of the Project	Financial Outlay (Rs. in lakhs)
1	2	3
$S_2G_6A_1P_1$	Strengthening of national network of Seismological observatories	75.00
2	Seismicity Survey of the country by the study of Microearthquakes and micro-tremor measurements.	15.00
3	Systematic study of earthquake mechanism in the Indian region	3.00
4	Preparation of a surface wave velocity Map of the country	6.00
5	Studies in Theoretical Seismology	3.00
6	Design and batch production of portable transducers, seismic amplifiers and pen recorders, tape recording seimographs, unmanned seismic station equipment, deep hole seismometers, precision chronometers.	50.00
7	Analysis of seismic waves due to artificial earthquakes including model studies. . .	1.00
8	Theoretical seismology study	5.00
9	Seismo-tectonic studies and possible prediction of earhquakes	1.50
10	Investigation of the structure of the Indian crust using deep seismic sounding technique .	45.00
11	Determination of the Regional Travel Time Curves for the Indian sub-continent and the upper mantle structure.	3.00
12	Development of methodology and preparation of quantitative seismicity maps of India/World.	3.50
13	Geophysical investigations directed to the prediction of earthquakes and effects of earthquakes on the human environment in India.	5.00
14	Investigations for Micro-zoning of various seismic regions for efficient and economic design of structures.	10.00
15	National strong motion instrument network	10.00
16	Study of the reservoir-associated seismicity	3.00
17	Earthquake source mechanism studies	3.00
18	Engineering seismological and earthquake engineering studies in connection with design, development and execution of river valley projects and allied research	20.00
	Total A_1 :— .	262.00

A_2 : Geo-Magnetism and Geo-Electricity

Project Index No.	Title of the Project	Financial Outlay (Rs. in lakhs)
$S_2G_6A_2P_1$	Observatory Organisation	20.00
2	Research in Geomagnetism (including instrumentation)	150.00
3	Geomagnetic Surveys	10.00
4	Measurement of magnetic & electric field components in the equitorial ionosphere . .	24.00
5	Geoelectricity	5.00
6	Miscellaneous capital works Programme	25.00
	Total A_2 .	234.00

A_4 : Geothermal Resources

Project Index No.	Title of the Project	Financial Outlay (Rs. in lakhs)
$S_2G_6A_4P_1$	Geo-thermal exploration of North-Western Himalayan Hot Spring (Excluding Puga and Manikaran areas).	5.00
2	Geo-thermal exploration in Puga valley (Ladakh) Hot Spring Region	25.00
3	Geo-thermal exploration of Hot Springs along Narmada Sone Lineament, Bihar and West Bengal.	5.00
	TOTAL A_4 .	35.00

1	2	3
	A_5 : Palaeogeophysics, Geodynamics and Physical Properties of Rocks	
$S_2G_6A_5P_1$	Study of the Archaeogeomagnetic field in India	2.00
2	Palaeomagnetic studies on the Decan traps	1.00
3	Palaeomagnetic studies of iron ore deposits of Singhbhum	1.00
4	Palaeomagnetic studies of rocks from the Himalayas	1.00
5	Palaeomagnetic and Geochemical study of mafic rocks of Bhowali, Manali and Panjal traps.	2.00
6	Palaeomagnetism of the Cuddapah and Kurnool formation & the dykes from South India.	
7	Palaeomagnetic studies of rocks in Cuttack & Singhbum districts	1.00
8	Palaeomagnetism of (a) Gondwanic sediments and associated rocks & (b) anomalous magnetisation zones reported by aeromagnetic surveys.	3.00
9	Palaeomagnetic investigation on upper mantle rocks of South India	1.00
	Geodynamics :	
10	Palaeomagnetic study of the tectonic of Narmada valley and Cuddapah Basin	1.00
11	Structure of tectonics of northern part of Cuddapah basin by seismic and electrical sounding methods.	3.00
12	Study of earthquake mechanism in the Himalayan region and the Andaman Nicobar Region.	1.00
13	Seismotectonics of the Himalayas (Integrated geological & geophysical investigations in the Himalayas).	35.00
14	Regional Gravity studies in India	3.00
15	Development of methodology and preparation of quantitative seimicity maps and regional tectonics.	3.00
16	Studies on the thermal regime of the earth's crust and standardisation of heat flow data in India.	10.00
17	Integrated geo-physical studies of rift valleys in India	1.00
18	Tectonics of Indian Sub-continent using palaeomagnetic data	1.00
19	Geo-chemical studies of volcanic rocks of India	1.00
20	Rocks mechanics and dynamic processes in the earth's interior	15.00
21	Tectonic investigation around Indian off-shore regions	10.00
22	Tectonic features and associated dynamic processes in the earth's interior	5.00
23	Seismo-tectonics of peninsular India with mobile observatory studies	5.00
24	Dating aspects of radioactive and radiogenic isotopes	1.00
25	Geological, geo-chemical and geo-physical studies of parts of the Decan Flood Basalts in India.	2.00
26	Seismic sources and fault plan studies for Himalayan region	1.00
	Physical Properties of Rocks :	
27	Study of elastic and electrical properties of rocks	1.00
28	Measurement and analysis of some physical properties of rocks	1.50
29	Magnetic properties of basalts from Peninsular India and Himalayan rocks	1.50
30	Study of electric & magnetic properties of rocks	1.00
31	Studies on U,Th and K contents in rocks of the Peninsular shield	2.00
32	Measurement of the velocity and attenuation of ultrasonic waves in rocks	1.00
33	A Study of radiation damages in rocks and its application	2.00
34	Magnetic and geological studies of the iron ores and associated rocks of the iron ore districts of Orissa and Bihar.	2.00
	TOTAL *A5*	12.00

1	2	3
	A_6 : Instrumentation for Earth Sciences	
$S_2G;A_5P_1$	To develop, design and fabricate different types of magnetic and magneto-telluric instruments.	13.00
2	*Meteorological Instruments.* (i) Improvement of temperature and humidity sensors, dropsondes, hypsometersondes, transponder sondes, dew point sondes, low level sounding systems, and the analysis of multi-parameter data using on-line digital computing methods for weather oriented decision making. (ii) Aeronautical meteorological instruments such as skopgraphs, ceilographs, CWIS instruments.	25.00
3	Development of digital field systems, non-explosive sources of seismic energy, digital grade geophones, well loggers, production logging equipment, expandable and semi-expandable jet perferators, side looking sonars, sparkers, sea bottom survey equipments, hydrophones.	15.00
4	(i) Consolidation of airborne pulsed e.m. systems-development, performance assessment (ii) improvement of fluxgate megnetometers. (iii) completion of Rubidium vapour magnetotemeter and development of caesium vapour magnetometers including flight test. (iv) Development of light version of I.P. Survey instruments. (v) Aircraft position location system. (vi) Digital recording system, off-line processing system for airborne data. (vii) Development of signal enhancement seismography simple-to-operate resistivity and S.P. Meters, magneto tellurimeter, multi-parameter well loggers. seabottom thermographs, sea bottom profilers, automation of water level recorders without floats for use in bore wells, airbone radar for determining the conductivity and dielectic constant of top soil.	71.20
5	Instruments in oil sector and for oceanographic work includes : Digital field systems, solid state analog reflection/refraction seismic unit, seismic source synchroniser, digital grade geophones, non-explosive energy sources, hydrophones, sparker equipment, sonar, water break amplifier, marine magneto-meter, stabilised marine gravimeter system, automatic multi-purpose logging unit, temperature proof well logging devices, tools for sonic logging, micrologging, side logging electronic thermometer, inpulse neutron generator, double channel radio active logging devices, magnetic sonde, electro-logging winch, tension meter, induction logging tool etc.	81.60
6	Improvement of strong motion accelerographs, structural response recorders, seismoscope, tilmeter, water tube and horizontal pendulum type development of strain meter.	7.00
7	Instruments relevant to exploration and exploitation of atomic minerals : (i) Sophistication of the Gamma-Ray spectrometer. (ii) Airborne proton precision magnetometer, I.P. frequency and time domain system, mass spectrometer (potassium, argon) neutron activation techniques for survey of the sea-bed, neutron activation borehole logging system and computer compatible data acquisition system for integrated airborne surveys.	26.20
8	(i) Land based prospecting and ore beneficiation instruments including X-ray fluorescence apparatus. (ii) Futuristic instruments and technique viz. acoustical telegraphy, side looking radars, air sampling and optical interferometry techniques for mineral exploration, gravity meters (seaborne and borehole) accelerometers, magnetometers for measuring horizontal gradient.	45.00
9	Development of magnetic and galvanometric recorders, special mechanical components .	46.00
10	Geodetic equipments viz. VLB I system, lasers, cameras, georeceivers, doppler transmitters	25.00
	TOTAL A_6 .	355.00

HIGH LIGHTS OF IMPORTANT R & D PROGRAMMES

Strengthening of National network of Seismological Observatories.

The existing network of seismic stations in the country is not adequate enough for monitoring the earthquake activity in the various seismic zones affecting it. The proper mapping of the seismic activity can be done only with an increased network. The better monitoring of the earthquakes affecting the various parts of the country will enable a much better evaluation of the seismic risk. This will help in proper precaution to be taken in the construction of various projects thus ensuring their safety. This would also reduce the over designing against seismic forces which is likely with inadequate data and therefore effect considerably to economy. The increased and more reliable data will help a better correlation of the earthquake occurence, with geological and tectonic feature and also help in better understanding of the nature and causes of earthquakes, ultimately helping man in his attempts at their prediction.

India Meteorological Department has the requisite experience of running a seismic network. Many of the instruments needed can be constructed in the workshop of the department.

Designing of Instruments and Batch Production.

At present, the instruments used in the country for seismic observations are the old conventional type, recording on a photographic paper. The whole observational set up therefore happens to be a little complicated and not easy to arrange in a short time. With the projected studies in various branches of seismology during the coming years, it is necessary to use instruments which can be easily transported and installed with the least amount of initial preparation yet with as high an accuracy as possible. In order to avoid importing these instruments from abroad, it is essential to take up their design and production in the country.

Necessary expertise and facility for the construction of the conventional type of seismic instruments are available in the Indian Meteorological Department. Facilities of electronic laboratory also are available in this department. The success of this project will make the country self-sufficient even in the modern sophisticated instrumentation and would pave the way for rapid increase in seismological studies.

Deep Seismic Sounding Studies in India.

The main objective for Deep Seismic Sounding (DSS) studies in India, is to determine the crustal structure in different geological provinces of the country, with proper volocity estimates in the various crustal layers and their depths upto and immediately below the Moho boundary. Uptil now, no quantitative study has been made of the crustal structure in any part of India and in the absence of this information, it is extremely difficult to determine regional travel time curve which are very essential for accurate location of epicentres of earthquakes and nuclear explosions. It is also difficult to establish the real cause and nature of gravitational and magnetic anomalies.

Some regional seismic exploration work has been carried out by the Oil and Natural Gas Commission and the Geological Survey of India. Yet till today, no Deep Seismic Soundings (DSS) have been undertaken in India. DSS is considered as a very powerful tool for detailed study of the earth's interior. The study will be useful for investigating earth's crust's leading to the discovery of new one deposits, and for finding out the relationship between the distribution and character of geological structure and the abundance of useful mineral resources related to them. The study will also be useful for the preparation of a very accurate tectonic and seismic map of India.

The project of Deep Seismic Sounding has already started functioning since 1972 under a joint Indo-Soviet Collaboration agreement which will be terminated after three years or so. The present scheme has been suggested with a view to continue the work with Indian know-how to be acquired during the time of collaboration.

Geophysical Investigations directed to the prediction of earthquake and effect of earthquakes on the human environment in India.

The present knowledge in the proposed area of research is still very incomplete since the beginning of the planned efforts even in Japan and USA in 1962 and 1965 respectively. In India a beginning has been made in 1969 and some studies in the Koyna and the Dakpathar (Dehra Dun) regions have been taken up. In view of the economic development of the country, relatively minor investment in a well-planned programme on prediction of earthquake and their effects shall result into the adoption of appropriate measures for the minimisation of loss of life and limb as well as reduction in destruction and damage to property. The study shall provide most valuable data for the Indian Region with regard to the concept of plate tectonics and the continental drift. For this purpose, it will be necessary to augment observations of geomagnetism and earth currents, gravity changes and seismic wave velocity preceding large earthquakes. The school of Research and Training in Earthquake Engineering, University of Roorkee has already initiated the studies in this field in a limited scale. Requisite instruments for intensification of studies are under development in this institute and some will be procured from outside.

National strong motion instrument network.

The main objective of this programme is to provide the basic engineering data needed for various seismic regions in order to permit scientific and economic design of structures and better understanding of earthquake source mechanism. The School of Research and Training in Earthquake Engineering has designed and developed number of strong motion instrument namely strong motion accelerographs, multiple structural response recorders and seismoscopes. It has been suggested that the School of Research and Training in Earthquake Roorkee should be responsible to design, development and manufacture of low cost strong motion instruments and structural response recorders so as to attain self-sufficiency in these areas of instrumentation.

Engineering seismological and earthquake engineering studies in connection with design, development and execution of river valley projects and allied research.

Engineering seismology and earthquake engineering studies are important aspects of design, development and execution of river valley projects. Collection and utilisation of basic data pertaining to design and execution of river valley projects in seismically active regions of the country is a stupendous work. Central Water Power and Research Station (CWPRS), Poona has been doing this work in a modest way with the available talent and equipments with them. It is envisaged to extend the field of this activity to many new project sites in the country where similar data are required to be collected. CWPRS, Poona has facilities for undertaking studies pertaining to the needs of the river valley projects, macroseismic regionalisation of river valley project areas, model testing of structures for dynamic response on vibration table, non-destructive testing of construction materials under laboratory and field conditions etc. The project would cater the growing needs of water and power resources of the country.

Earthquake Source Mechanism studies.

The Himalayan mountain belt is particularly an important seismic region because of its location between the two countries—the Indian sub-continent and Eurasia. Source mechanism study is the only method which provides direct evidence of tectonic movements and deformations taking place deep inside the earth. Seismic slip obtained by source mechanism studies will give the direction of the relative movement between the two plates involved. The country has already attained experience in studying source mechanism for the reservoir and earthquakes in Assam and Burma regions but focal mechanism solutions of earthquakes in Himalayan region is still lacking and it is desirable to determine more solutions.

The study of earthquake source mechanism will involve tectonic directions, nature of stresses, dynamic processes and the relations to geological structure in the Indian sub-continent. It will also provide clues for evaluation of Himalayan and plated tectony in this region. It will be used for the investigation of dynamic processes responsible for crustal thickening of Himalayas. Relationship, if any, will be examined between tectonic events in the Peninsular India and sea floor spreading.

Researches in Geomagnetism.

The importance of the study on the main magnetic field of the earth, its origin and variations and its relations to events in the sun are useful inputs to the prediction of the terrestrial effects like disruption of shortwave radio and cable communications and also for examining the biological effects of the magnetic disturbances. With the advent of space era, the study of the Earth's magnetic field and the interaction of solar plasma with it have assumed immense importance for space work. As such this study will make valuable contribution in the field of space research. The study of magnetic anomalies will be helpful in the development of tectonics for the prediction of earthquakes.

The Indian Institute of Geomagnetism has a tradition of research contribution in geomagnetism, extending back to a century and quarter. The National Geophysical Research Institute, Physical Research Laboratory and Indian Institute of Astrophysics have well-equipped sections on geomagnetism. Under the project the Indian Institute of Geomagnetism will intensify study in applied research. A survey of the equatorial electroject region in India and coast lines effect on the magnetic variation will be undertaken jointly by the Indian Institute of Geomagnetism, National Geophysical Research Institute and Survey of India. The study of the geomagnetic anomalies in relation to tectonics which may prove valuable in the prediction of earthquakes, and investigation of the biological effects of geomagnetic disturbances will be taken up at the National Geophysical Research Institute.

Measurement of magnetic field components in the equatorial ionoshere.

Component measurement of electric and magnetic fields in the ionosphere is essential for understanding the mechanism of the ionospheric phenomena associated with the currents in the ionosphere. Such study will solve a classical problem of the origin of the diurnal variation of geomagnetic field. The existence of vertical and meridional current flow within the ionosphere near the magnetic equator cannot be detected by the ground based instruments alone. We have the advantage of having rocket launching station at Thumba near the magnetic equator wherefrom rocket facilities could be availed of for conducting magnetic and field measurements in the ionosphere. For this purpose, it will be necessary to develop the latest types of magnetometers, electric field probes, gyros and other types of altitude determining equipment. The knowledge gained by the R&D work carried out under this project which includes development of sensors, sub-systems etc. will find use in defence, industry, and magnetic exploration work

During the past eight years of research and development activity at PRL, SSTC and TERLS, facility to instrument rocket payloads and to successfully carry out rocket-borne scientific experiments have been set up in the above institutions. It will be necessary to set up some test and evaluation and data reduction facilities at the above-mentioned centres to carry out the proposed programme. The group has identified that PRL will instrument the electric and magnetic field probes (sensors), associated electronics, ground support system and data reduction systems. The probe development mechanism and associated timers and electronics will be engineered and executed by TERLS (ISRO). SSTC will process the data from the gyros.

Geothermal Exploration in Puga valley (Ladakh) Hot Spring Region.

The present power generation is by diesel sets and the heating requirements are usually met with kerosene, involving expensive transport of the fuel. No natural fuel resources are available in this region. It is expected that the generation of power from geothermal resources would be an economical proposition as compared to other sources of power. The power generated, can be utilised by the Armed Forces Establishments in the region and for local needs. The thermal water can also be used for the provision of hot water supply for baths in barracks, space heating for the defence personnel and for gree-house cultivation etc.

NGRI had carried out preliminary temperature survey in the Puga valley during 1967 and detailed temperature surveys at a depth of one-meter in 1970. G.S.I. has done the geological mapping of a part of the area during 1962-63 and has drilled about 16 shallow holes (50 metres) in the valley for borax and sulphur exploration in 1968-70. Hot water and steam under pressure have been encountered in 12 out of 16 boreholes. Water and steam, from some of the boreholes have gushed up to a height of 60 feet. The temperature of water ranging from 50°C to 110°C have been observed. These studies have indicated that the shallow temperature gradients and the conductive heat flow in the valley are much higher than those in the normal continental areas. Under this project, it has been envisaged that the extent of the geothermal fields and characteristics of the geothermal reservoirs will be defined by carrying out the various surveys such a infrared, resistivity, magnetic, seismic refraction, geohydrological and temperature at one metre depth.

Study of Archaeogeomagenetic Field in India.

Recent and archaeomagnetic studies suggest that both the geomagnetic dipole moment and the non-dipole moment show in the first appoximation, a sinusoidal variation with a quasi-period of about 9000 years. This field variation bears an approximate inverse correlation with the radio-carbon variations and also geomagnetic variations. Future research is likely to reveal whether the fluctuations of the geomagnetic field strength indeed modulate the climate. With these objectives it has been suggested to study the nature of intensity and secular variations of the archaeogeomagnetic field and the contribution of non-dipole components in the overall picture of the archeogeomagnetic field. It has also been suggested to study the relation between archaeomagnetic field relations and variations in radio-carbon production rate.

Researches in Palaeogeophysics.

The appreciation of the origin and the evolution of the solid earth to its present state has hitherto been limited owing to the absence of appropriate information regarding the history of the solid earth itself. Under the scope of this branch of science falls (a) Geophysical measurements of the global properties and (b) the comparsion of the parameters thus measured with other planetary bodies. While the latter has advanced much in the recent years with rapid developments in the radar and radio methods of space technology, it is imperative for its appreciation of the solid earth that the present global observations be projected backwards in time, which falls under the scope of palaeogeophysics. The aim of palaeogeophysics is to provide measurements of the parameters of the earth in the geological past, such as determination of any changes in the earth's magnetic field, radius, thermal behaviour continental configurations, polar wandering etc.

Studies on various aspects of palaeogeophysics have been carried out in many universities and educational institutions with a view to intensify research on understanding the evolution of our earth. The group has identified a number of research projects to be implemented by a number of universities and educational institutions.

Studies on Seismotectonics of the Himalayas

A wide perspective of the Himalayas in relation to the adjoining geological realm, highlighting the past and the present geodynamical processes operative in the region will provide information on (a) evolution of the Himalayas, its tectonic history and structure ; continental drift plate tectonics and mantle phenomena; (b) occurrence of mineralised zones and geothermal sources and possibility of their exploitation and (c) activity of thrust zones with a view to optimising civil engineering design and construction in river valley and other industrial projects in the Himalayan region. Thus, these studies are expected to evolve meaningful criteria for statistical risk prediction. Therefore it has been suggested the geotectonic investigations in the cruical areas of the Himalayas and the gravity, magnetic and paleaomagnetic studies relating to the investigations of dynamic forces giving rise to thrusts, intrusions, etc. should be undertaken in the country. In association with the seismological studies in the thrust zones, geothermal studies of hot springs both in the Great Himalayas and in the thrust zones, should be undertaken in order to arrive at effective results.

Studies on the Thermal Regime of the Earth's Crust and Standardisation of Heat Flow data in India

Preparation of a detailed subsurface temperature map for the country is important for the determination of radioactive elements e.g. U, TH and K. For this purpose, a detailed study of surface heat flow through various geological and tectonical layers with a view to analyse and inerpret it in relation to radioactive heat generation, regional geology, tectonics, etc., are necessary. In order to understand the Indian data better and also to indicate a programme of measurement of oceanic heat flow, it will be necessary to analyse the global thermal field in relation to other geophenomenon.

Studies on Physical Properties of Rocks

Studies of the various physical characteristic of rocks such as elastic, magnetic, electrical, thermal and radiometric properties and density, the nature of these properties and their variations with petrology, petrography and petrochemistry, are important for studying the surface and subsurface configuration of rocks and rock structures.

In the filed of elastic properties of rocks NGRI has emerged as the leading centre in the country for the study of these properties. They have already fabricated the high pressure equipment upto 5 K. Bars and 30 K. Bars high pressure equipment is under design and development.

In the field of magnetic properties on rocks, studies are now being carried out at the Tata Institute of Fundamental Research, National Geophysical Research Institute, Osmania University, Andhra University; Indian School of Mines, S.V. University etc. More detailed studies should be made on rock formation in areas where strong anomalies are observed in grand and aeromagnetic surveys.

In the field of radiometric properties, the NGRI has already acquired 256 channel gamma-ray spectometer for studying the property of rocks. The Centre of Exploration Geophysics, Osmania University has recently started conducting investigations on the radiometric properties of rocks. Considerable work on this subject is being conducted by the Atomic Research Centre, Tata Institute of Fundamental Research. Studies on these aspects of rocks should be intensified for several geological terrains such as the peninsular granites and gneisses, and Cuddapah basin etc. A number of projects have been identified in these areas which have to be implemented by institutions like NGRI, Osmania University, Kurukshetra University, Calcutta University and ISM, Dhanbad.

Development of Magnetic and Galvanometric Recorders

Considering the tremendous advantages of data acquisition in magnetic tape format, it is important to initiate a crash programme for standardising a portable 4 channel version, as well as a 14 track 1/2″ laboratory version of analog magnetic tape recorders and a 1/2″ tape recorder and to ensure a time bound programme for their development within the country. It is essential to extend this effort to the development of multi-track visual recorders of the galvanometric type using heat sensitive paper. At present, there is a wide gap in the developments o magnetic and galvanometric recorders in the country.

Design and Development of Ground Based Geophysical Prospecting Instruments

The country has at present adequate technical competence for undertaking research an development work in the field of ground based geophysical instruments. The main lacuna i their development is the lack of adequate field data regarding the performance of instrument developed by various institutions. The group has identified institutions and the types o instruments which are needed in large numbers and which have been developed and engineere by them to an advanced degree of perfection. The institutions identified for these work ar NGRI, ONGC, BARC, AMD, etc. The group has also identified a large number of ground base geophysical instruments which need be developed in the country in order to save import fro abroad. It has further been suggested that there should be clearly specified time targets lai down for the development and manufacture of instruments and once the timebound developme and manufacturing schedule becomes operative, it should be mandatory on the different use organisations to use only the instruments made in the country, whenever such instruments ar available.

SECTOR—MARINE RESOURCES

MARINE RESOURCES

ntroduction

The oceanic environment and the resources available therein represent one of the least xplored and exploited frontiers in the Indian technological and economic framework. Although he fisheries potential from the Indian Ocean has been estimated to exceed 10 million tonnes, ndia's catch of 1.8 million tonnes remains very small especially when compared to her needs. he Indian fishing fleet is largely composed of non-mechanised boats using age-old methods and ear without showing much signs of scientific/technological impact of the 20th century.

The energy resources, *i.e.* oil and gas, which have been scarce commodities for India, are oing to be in short supply the world-over. Large reserves of oil and gas are expected to occur ff our coasts in the continental shelf and adjoining sediments. Although, drilling efforts are eing made at the moment, the technological capabilities required in almost all the related marine ields are lacking, thus compelling India to look to foreign assistance even in the smallest of hese operations.

In the case of hard minerals, though indications are available that a variety of minerals mportant to our economy occur off our costs and in deeper areas, a serious technological ap exists even in the exploration effort. Consequently, no capability has been built for the ecovery, production and transportation of these minerals.

The limited use of oceanic resources has also been due to a direct result of our inadequate nowledge about our marine environment and its physical, chemical, biological and geological haracteristics. This environmental information is basic to any work in the marine environment and is of great potential use to the navy as well.

Basic to our effort for the utilisation of our marine resources more effectively, is the need to evelop indigenously our technological capabilities. Once developed, these capabilities will ermit substantial savings in foreign exchange and in total costs to the economy and allow the mergence of self reliance in a critical sector of our national life. For, offshore technology s an area of threshold technology requiring a multi-disciplinary approach and having a large mount of fall out effects in related areas. Not only can it be used for offshore oil exploration and production, when developed, this technology ould also be utilised by the country for its offshore oil terminals for receiving ery large crude carriers, for submarine pipelines, for export of iron ore slurry, offshore lighthouses, ports and harbour development works and for various naval works. The development f offshore technology would imply an adequate planned investment in areas varying from nderwater welding to oil pollution control, from offshore drilling technology to laying of submarine pipelines using indigenous equipment.

According to the projections of the Ministry of Petroleum & Chemicals and the Planning ommission, it has been estimated that in 1978-79 our annual crude oil requirements would be f the order of 42 million tons, while the total production, due to a fairly ambitious onshore programme and rudimentary offshore programme, with an outlay of Rs. 624 crores (of which Rs. 166 crores is to be in foreign exchange), would be 11.4 million tons. This would require an import of 30.6 million tons of crude oil at an annual cost of Rs. 480 crores in foreign exchange in 1978-79. And this foreign exchange outflow will increase progressively if no indigenous crude oil is discovered in our onshore and offshore areas. In view of these anticipated shortages as well as the magnitude of the capital required for exploring and exploiting crude oil reserves in the offshore areas, where according to the Ministry, existence of large reserves of oil is most probable, the government has recently enunciated a policy for foreign collaboration in the offshore areas. There would therefore be an intensified effort in the next decade for exploration of oil in our offshore areas not only by the Oil and Natural Gas Commission but also by various foreign companies operating under the new guidelines published by the Ministry. It is necessary to point out that the major portion of investment in offshore oil exploration occurs in the commercial production phase, and the investment relevant to commercial production are heavily dependent on the cost of installation, development drilling, submarine pipeline, transportation, production platforms, offshore oil storage etc. Another area of heavy investment is that on construction equipment which would be required for the installation work in the offshore areas. By a planned investment, however, it should be possible to obviate the need for renting heavy construction equipment from foreign sources at the rate of 40,000 to 50,000 dollars per day. This planned investment has to be undertaken along with the development of capabilities in design installation and operation for offshore oil fields within the next 3 to 5 years. Since i would take at least 2 years from now for commercial reserves to be proved, if a parallel actio is initiated in both exploration and production, a substantial portion of the hardware and softwar required for production could be made available from indigenous sources by the time commercia reserves are proven either by our own offshore unit or by the foreign companies operating i our waters. This would greatly reduce the dependence on large investments to be made by foreig companies for the production operations and consequently reduce the foreign exchange outflow or the need for selling our crude oil to pay for their services.

In view of possible short falls in crude oil, it would be necessary for India to import larg quantities of crude oil from oil producing countries. It is anticipated that the refining capaci by 1978-79 would be of the order of 36 million tons requiring the import of substantial cru oil. Since the cost of transportation of crude oil forms an important part of the total cost pa by the country for import of crude, it would be desirable to explore ways and means of reduci transportation costs. Table I indicates the relationship of transportation cost to that of the si of tankers and shows that substantial economies are possible if larger tankers are used. It important to note, however, that the very large crude carriers require the development of offsho terminals since the existing port handling capacity within the country and even those plann for the next 10 years do not permit the use of very large crude carriers. In Table II a rou estimate has been made of the freight savings possible by using very large crude carriers (that VLCC class of tankers 160,000 tons and above) as compared to the present MR or LR cl tankers. Some other advantages of providing suitable offshore oil terminals for VLCC t tankers for import of crude oil or export of iron ore slurry are that as oil traffic represents ab 1|3rd of the total traffic dealt with by our ports, substantial capacity would be released for ot traffic. Comparatively the magnitude of investment required for creating conventional t berths and other facilities at the ports and normal dredging for dealing with the increased volu of oil traffic would probably be 5 to 10 times more than that would be required for putting offshore terminals. The technology that is developed for offshore oil production and opera can also be utilised for the design, fabrication and installation of offshore terminals. Furt since offshore terminals require considerable maintenance it would be necessary for the cou to develop adequate supporting services such as underwater welding, cutting, precision-nav tion, submarine pipeline, oil pollution control systems etc.

TABLE I

Relationship of transportation cost to the size of tankers

Distance in miles for round trip.	Cost in US $ per ton for the tanker size in 1000 tons								
	20	30	40	50	60	70	80	90	100
3000	1.8	1.4	1.2	1.0	0.9	0.05	0.85	0.8	0.80
5000	2.7	2.2	1.8	1.6	1.4	1.35	1.25	1.2	1.12
8000	4.0	3.3	2.8	2.4	2.2	2.00	1.09	1.8	1.70
10000	5.4	3.8	3.2	2.8	2.6	2.04	2.02	2.1	2.00
16000	—	5.8	4.8	4.2	3.7	3.05	3.02	3.1	2.90

TABLE II
Freight savings per year

(In rupees/crores)

Name of the Port	1976	1978	1980
Bombay	2.2	2.9	2.9
Goa	2.0	3.1	3.1
Cochin	3.2	3.2	3.2
Madras	1.6	1.6	3.2
Vizag	2.0	2.0	2.5
Haldia	5.7	8.8	6.5
Salaya	3.1	6.3	9.9
TOTAL	19.8	27.9	31.3

Offshore technology would also prove to be of considerable use in the Ministry of Defence's naval projects. Various ports and harbours in their expansion programme would require the development of new offshore equipment and techniques. The Deptt. of Lighthouses and Lightships has drawn up a 10 year programme which includes design, fabrication and installation of fixed type lighthouse platforms for navigation of large crude carriers. A number of related projects such as installation of an early warning weather systems in the sea, oil pollution control measures, fisheries development projects etc., would all require the early development of offshore technology indigenously.

Some of the other significant factors which need to be stressed in our efforts to develop technology and technological self reliance in the area of marine resources are the following. There is a need to develop an integral approach in undertaking various surveys for collection of oceanographic, biological, geological and other data. Since the costliest part of the survey programme is the purchase and maintenance of the survey vessel, it would be possible by good planning and management to cut down the unit cost of the information generated by combining the collection of data for a number of different survey activities. The need for such an integral approach is enhanced by the paucity of costly capital items. Furthermore, the information acquired by the various specialist field-agencies needs to be processed and compiled in a form which can cater to the needs of other user organizations as well. The information network that is required can form a part of the national information grid in such a way that it supplements data analysis and precessing facilities of the field agencies.

A major impact of developing the technology indigenously would be to reduce our dependence on foreign turn-key contracts, for exploration as well as exploitation of our marine resources. A majority of these programmes today are being carried out either completely, or largely through foreign organisations at substantial foreign exchange costs. A consequence of this dependence is that there is little utilisation of indigenous skills, nor utilisation of the production capacity in the fabrication and manufacturing organisations. The operational and maintenance requirements of equipment purchased from outside without a competent counterpart organisation leads to recurring demands for expertise and spare parts from outside. These aspects emphasise the desirability of setting up indigenous engineering design. and instrument design organisation or teams. Not only would such technological skills make available designs and know-how but would also permit rapid adaptation of imported designs and know-how to suit Indian materials, equipments and instruments. The effect of indigenous design effort, and research, would be to lead to a substantial reduction in the import of capital items, instruments, and bulk materials.

An integrated plan of action taking into account the existing capabilities of Indian organisations as well as the requirements of various user agencies has been evolved by the NCST Panel on Marine Resources. A summary of their draft plan for the marine resources of the Fifth Five Year Plan is presented here. This has been prepared through 9 planning groups in the following areas:—

1. Fish and Fisheries.
2. Environment.
3. Sea Water.
4. Marine Instruments.
5. Information Management & Data Collection.
6. Research and Education.
7. Equipment.
8. Minerals, Oil and Gas.
9. Coastal Zone.

These Planning Groups involve over 180 individual scientists and technologists all over the country both from the private and public sector organisations. Based on the various planning groups' reports and the seminars held by the NCST, the major objective and programmes for the Fifth Five Year Plan have been identified and their financial as well as institutional implications worked out.

II. *MAJOR OBJECTIVES AND PROGRAMMES*

Build up of technical capability leading to self reliance inmarine area can only be achieved through undertaking a coherent long-term plan that would serve India's marine interests and needs. In the following paragraphs, the areas and the nature of the work to be undertaken on a long term basis, is indicated. In this sense the programmes composing the marine resources S & T component of the Fifth Five Year Plan may be regarded as laying the foundation in a number of directions which enter this new area. The nature of field activities like exploration and extension services have been discussed below but they do not form a part of the component entering the S & T Plan. They have been regarded as activities to be undertaken under the normal mandate of the concerned Agencies or Ministries. However, the RDD inputs to the field activities in the form of design and development of suitable software, instrumentation, equipment and other systems required for these activities has been incorporated.

II. A. *The Marine Environment*

An understanding of the environment is an essential pre-requisite to explore and exploit it successfully. The oceanic environment needs to be observed, understood and predicted not only from the resource point of view but also for meteorological phenomena on land, shipping routes and ship designs, military needs and the multitudinous coastal usage. A comprehensive knowledge of the physical environment would have to be gathered by initiating the following programmes:

(i) A General Environmental Monitoring and Prediction System aimed at collection of oceanographic and meteorological data through larger number of voluntary observation fleet ships, stationary and free-floating buoy net-works, fixed platforms and remote sensors.

(ii) National Cyclone Warning and Research Centre for the detection and forecast of cyclones through radars and satellite stations.

(iii) Environmental Modification Programme resulting in beneficial modification of the environment, so as, to establish ecological balance in coastal polluted areas, etc.

(iv) Marine Biological Research to understand the dynamics of the ecosystem for prediction and ultimate control of biological events.

II B. *The Living Resources*

For a country with a large population and a perennial shortage of food, and of animal protein, India's marine fish catch of 1.8 million tonnes needs to be at least doubled in the next five years. This can only be done by improving the technical efficiency of harvesting the known stocks, locating and defining new stocks, recasting the institutional setting for fisheries management, developing new end-products from presently unutilised or underutilised species and opening up the new field of aqua-culture. RDD effort is required along the following lines.

1. Costal fishing improvement programme needs to be taken up to increase the productivity in traditional fishing by non-mechanised and mechanised boats. The return per unit fleet can be improved by providing better designs for vessels, engines, winches, seines, new improved materials, etc.

2. Offshore and deep-sea fishing programme should be launched to harvest known stocks with indigenous vessels. S and T inputs required are suitable designs for various types of fishing vessels locating of new stocks beyond 40 fathoms (75 meters water depth) and their harvesting.

3. Distant water fishing initiation of fishing in distant areas using self contained large mother/factory ships can be made by taking advance steps for design of the vessels, onboard systems and gears.

4. Development of processing facilities. The design and development of indigenous processing equipment and research on preventing fish spoilage on boats are essential for storage and distribution of marine fish to inland markets.

5. Fisheries survey and aquaculture should include research projects aimed at quick location and estimation of known and newstocks, increased use of environmental data, etc. and on evolving suitable techniques for aquaculture of important marine organisms.

6. Extention services are by far the weakest link in marine fishery development. These require organisational changes, setting up of training courses for the small users, distribution of scientific and marketing information and new techniques of fishing and processing.

II C. *The Non-living Resources*

Oil & Gas

In view of India's acute need for indigenous crude oil, a major break-through is required and the continental shelf appears to be the most promising area due to its vastness and large size of explored favourable areas. However, very little indigenous technical capability is presently available either to explore or to exploit the possible oil reserves. A number of research and development projects are urgently required to be started for developing these capabilities.

1. Seismic Survey and Interpretation Capability (Oil & Gas)

Indigenous equipment, manpower and know-how need to be developed. An up-to-date seismic vessel, onboard data processing hardware and a team of seismic experts should be acquired to carry out exploration surveys for oil on the continental shelf. Research programmes are also required to be undertaken on improving seismic survey and data processing techniques.

2. *Development of Offshore Technology*

One of the key elements which needs to be stressed is the development of Offshore Technology. For the development of offshore technology, a selective and integrated phased programme in various areas is to be organised. The following are some of the major areas to be developed;

(i) Marine investigation capabilities.
(ii) Offshore structures.
(iii) Production technology.
(iv) Transport of crude/slurry through submarine pipeline.
(v) Storage at sea.

(vi) Specialised support services.
  (a) Underwater technology.
  (b) Navigation aids.
  (c) Pollution.
  (d) Safety.

(i) Marine investigation capability.

The marine investigations which have to be carried before any offshore structure can be installed consist of—

(a) Oceanography
(b) Hydrographic surveys, and
(c) Marine soil investigations

These investigations require hardware like current meters, wave recorders, soil and seismic equipment, piston gravity corers, deep rotary coring rigs, remote control—soil testing equipment etc. and software such as computer programmes for prediction of oceanographic conditions, assessment of design parameters for environmental conditions determined from field investigations and from historical data collection and analysis.

Some sea bed investigations have already been carried out by CGG of France for the ONGC in the Bombay high area towards the month of November-December, 1972 in collaboration with EIL. Historical data collection and analysis of environmental conditions for a number of areas have also been carried out by EIL for ONGC, NMDC and the IOC. Some relatively unsophisticated hardware such as wave recorders, piston gravity corers are available with organisations like CWPRS, GSI and EIL. EIL has also recently purchased a shallow seismic profilling system which is the only unit at the moment in the country.

(ii) Offshore structures

Offshore structures are required for oil production at sea, lighthouses, signal point mooring systems, instrumentation platforms etc. and involve the design, fabrication and installation of fixed tabular steel structures in shallow and deep waters. The hardware required for carrying out this work consists of equipment for fabrication of large size tabular structures, floating construction equipment, like derrick barges for the installation work at sea, and pile driving hammers for pinning the fixed structures to the sea bad. The software required necessitate development of capability for the design and planning of these structures including computer programmes to simulate environmental conditions and analysis of response during the fabrication, installation and life time use.

In India, one fixed platform in shallow water was installed at Aliabet by the ONGC in 1969-70 based on the designs provided by the USSR. The fabrication and erection of this platform was done by ONGC using indigenous equipment. An analysis of the present status reveals that capability in design, fabrication and installation of offshore platforms at present are developed only for working in the shallow waters. While software has been developed in EIL for design of offshore structures in deep waters, the necessary fabrication capability and equipment for work in deep water is not available within the country.

(iii) Oil production technology

Oil production technology has to be developed in areas such as drilling directional wells, cementation, drilling fluids, chemicals etc. This production technology requires the development of suitable tools, instruments and equipment.

Since Oil & Natural Gas Commission and Oil India Ltd. have been working on land for a number of years, there is not only considerable hardware available but also the capability exists for evolving the necessary production technology for operation in the offshore areas with marginal inputs.

(iv) Transport of crude oil/slurry submarine pipeline.

Transport of crude oil/slurry from the source to the shore, or *vice versa*, is normally done through a net work of submarine pipelines. The submarine pipeline diameter ranges from 6 to 42 inches depending upon the quantity of flow, and the techniques involved are those of welding, weight coating, cathodic protection, pumping and laying of submarine pipelines in shallow and deep waters. For laying submarine pipelines close to the shore, a technique which uses barge mounted winches can be utilised, while for deep waters a derrick lay barge would need to be obtained. In any case, it would be necessary to set up plants for weight coating of pipelines and for their welding which requires special techniques and equipment. So far in this country there is only one submarine pipeline which was laid in 1953 from Bombay to Bucher Island. While some indigenous capability exists in the country for design of submarine pipelines and the laying of small pipelines from the shore, it would be necessary to organise them with suitable inputs from experienced agencies abroad, including purchase of equipments like lay barges, winches, coating plants etc.

(v) Storage at sea

In case of oil discovery at some distance from the shore, it would be necessary to store crude in the field, either in submerged storage tanks or in storage tankers moored nearby. This may also utilise a single buoy mooring system for loading and unloading of crude. The technology required for the design, fabrication and installation of suitable storage systems is similar to that required for the design and installation of offshore structures, although these may, sometimes, require the carrying out of suitable model experiments.

There are no offshore storage facilities in the country nor have any SPM system been installed. Detailed studies are, however, being carried out for the design, fabrication and installation of offshore terminals which could be utilised for loading and unloading of crude oil tankers or iron ore slurry tankers of over 100,000 dwt.

(vi) Specialised support services

To carry out any work in the offshore areas, a large number of specialised support services need to be developed:

(a) Underwater technology

Underwater technology consists of deep diving, underwater maintenance, repairs, underwater cutting, welding etc.

(b) Navigation aids

With the advent of giant tankers and bulk carriers accurate positioning will become necessary. Several electronic instruments are now available for this. Accurate position-fixing is also required for oil drilling production platforms, well location, excavation, submarine pipeline laying, SPM system etc. Besides normal aids such as offshore lighthouses, a number of electronic aids such as radars, radio beacons, low range decca, shoran, hi-fix, micro wave survey system, toran etc. have been developed.

India has a network of 3 major decca chains and a limited number of decca hi-fix chains are available with a few agencies such as Deptt. of Lightships & Lighthouses, Nawal Hydrographic Office, etc. Some of the port authorities also maintain limited navigational chains for their own dredging purposes. There is, however, no indigenous development of navigational aids to match the requirements in quantity or sophistication for the extended offshore programme now being envisaged.

(c) Pollution

With the increase in offshore activity through the production and transportation of crude oil, there are increased chances for oil spillage and pollution. The technology required for removal and disposal of oil requires suitable development of chemicals, mechanical equipment and organisation.

There are no capabilities within the country for tackling major pollution of oil spillage at sea. Very crude techniques are being utilised at present for removing oil spillage at sea by use of soaking straw. Minor spillage within the ports, however, can be tackled by use of suitable equipment. A detailed project report has been prepared by EIL for the Madras Port Trust for a suitable oil recovery and containment system.

(d) Safety

With the increased activity anticipated, offshore technology needs to be developed to handle accidents such as 'blow out', collision of vessels and salvaging of structures and vessels. This requires equipment and organisation for handling major fires offshore and for rescue and speedy rescue operations in case of collision of vessels.

Limited capability exists within the country for salvaging small crafts and diving capabilities are limited to less than 100 ft. of water.

A brief assessment based on the programmes drawn up by various agencies in the country for work to be carried out in our offshore areas over the next decade is briefly indicated below:—

(i) Offshore Oil Exploration & Production.

Based on the assumption of a minimum offshore crude oil production of 10 million tons per year in the next 10 years through programmes to be undertaken by ONGC and other foreign companies in Indian water, under the revised government policies, an assessment has been made for the hardware requirements for the shallow and deep water production and development. The requirement would be :—

(i) Fixed offshore shallow water structures	6 Nos.
(ii) Fixed offshore deep water structures	25 Nos.
(iii) SPM systems	2 Nos.
(iv) Submarine pipeline	380 KMs.

(ii) Transport of Crude Oil/Iron Ore Slurry Through Submarine Pipelines.

IOC has planned to install on SBM system and to lay about 10 KM submarine pipeline for its offshore oil terminal required for transporting crude oil to the shore for its north west refinery. The total financial implications of this offshore terminal and submarine pipeline is Rs. 7.4 crores of which Rs. 2 crores is for the SBM System and Rs. 5.4 crores for the 10 KM of submarine pipeline.

NMDC is contemplating installation of an SBM system and the laying of about 16 KM of submarine pipeline for the export of Iron Ore slurry from the Kudremukh Iron Ore Project. The total financial implications for the offshore terminal are approximately Rs. 10.6 crores with Rs. 2 crores being for the SBM system and and Rs. 8.6 crores for the submarine pipeline.

(iii) Other Offshore Projects.

The Deptt. of Lighthouse & Lightships proposes to build 5 offshore lighthouses in the Gulf of Kutch and Gulf of Cambay during the 5th Five Year Plan, and is also contemplating putting up 5 additional offshore lighthouses in the succeeding 5 years. The total financial cost for the design, fabrication and installation of these 10 offshore lighthouses works out approximately to Rs. 15 crores.

There would also be an additional requirement for installation of offshore/structures such as single buoy mooring, instrument platforms, submarine pipeline etc. for the import of crude oil. A detailed assessment of the additional offshore oil terminals that would be required has not been made, but as has been indicated above considerable savings in foreign exchange are possible if offshore terminals suitable for handling very large crude carriers of over 160,000 dwt are installed by 1978-79.

It can thus be seen that the total cost for the design, fabrication and installation of various kinds of offshore structures over the next 10-year period estimated by the various agencies in the country would be of the order of Rs. 340 crores with a foreign exchange component of Rs. 270 crores. (These figures are based on an oil production of only 10 million tonnes per year). If the additional offshore oil terminals necessary for import of crude oil are also installed, the total cost would rise to a figure of approximately Rs. 400 crores (F.E. component Rs. 330 cr.) In addition to these costs for structures, if production technology for offshore oil drilling is indigenously developed, considerable savings in foreign exchange would be possible.

Based on the known programmes of the existing agencies, a brief estimate has also been made of the requirements for the steel and equipment.

The steel required for the fabrication of the above offshore structures would be of the order of 1,75,000 tons and of this, 1,55,000 tons would be in the form of pipes made from strips and sheets and the rest in the form of structures conforming to IS 226 and IS 2062. Of this 1,55,000 tons of steel, 90,000 tons shall conform to API Std. 5 LX-X 52 and the rest to API Std. 5 L grade B. Since offshore structures are generally tubular in nature with the diameter ranging between 6 to 42 inches and thickness between 0.375 to 1.5 inches, it would also be necessary to set up adequate fabrication facilities.

The equipment required for the fabrication and installation of these structures are given in Table III. It has been estimated that if the above equipment are hired from abroad rather than purchased out-right at the commencement of the oil production programme, the hire charges would be of the order of Rs. 28 crores, in foreign exchange, as given in Table IV.

It is expected that the total cost for the design, fabrication and installation of these major production structures would be of the order of Rs. 340 crores as given in Table V.

TABLE III

Equipment to be Imported & Breakdown of Cost

Item	Nos. required	Approximate amount in Rs. crores
1. Ocean going derrick cum pipe laying barge	1	10.0
2. Ocean going flat deck cargo barges		
Approx. sizes 120 M x 30 M	1	2.0
105 M x 25 M	1	1.5
75 M x 25 M	1	2.0
60 M x 20 M	1	

1	2	3
3. High power tug cum anchor shifting vessel 4000 HP.	2	2.0
4. Crawler cranes—capacity 150 t.	8	1.5
5. Offshore pile hammers		
60,000 ft. lbs. capacity	2	0.3
120,000 ft. lbs. capacity	1	
200,000 ft. lbs. capacity	1	0.2
6. Concrete coating plant	1	0.5
7. Underwater cutting & Welding tools	—	0.4
8. Deep diving complex	—	0.5
9. Navigational aids like shoran, toran etc.	—	1.0
10. Shapped charged explosive cutters	—	0.4
11. Heavy anchors & winches	—	0.4
12. Stringers	—	0.5
13. Habitat	—	0.5
14. Misc.	—	3.3
Approximate total (in foreign exchange)		27.0

TABLE IV

Hire-Charges of Equipment with Services

S.No.	Description	Mob. days d_1	Demob days d_2	Working days d_3	per trip day $d_4=d_1+d_2+d_3$	Nos. of trips n	Total days $n \times d_4$	Rate in Rs lakhs/day	Total in Rs. lakhs.
1.	Ocean going derrick cum pipe laying barge—1 No.	15	15	50	80	10	800	3.00	2400
2.	High Power Tugs—2 Nos.	15	15	50	80	10	800		
3.	Offshore pile hammers 2 Nos.	15	15	50	80	10	800		
4.	Stringer—1 No.	15	15	50	80	10	800		
5.	Heavy anchors and Winches.	15	15	50	80	10	800		
6.	Deep diving complex	15	15	30	60	10	600	0.10	60
7.	Habitats	15	15	30	60	10	600		
8.	Crawler crane—1 No.	15	15	100	130	10	1300	0.05	65
9.	Ocean going flat cargo barges with tugs—2 Nos.; 120m × 30m.	15	15	50	80	10	800	0.20	160
10.	Navigational aids e. g. shoran etc.	5	5	30	40	10	400	0.10	40
11.	Misc equipment e.g. under water cutting & welding tools, explosives, cutters, etc.	—	—	—	—	—	—	—	75
	(Rs. 28 crores in foreign exchange)							TOTAL	2800 lakhs

TABLE V

Total Financial Implications for Development of Offshore Production—Next 10 year Programme

S.No.	Description	Nos.	Unit cost in Rs. crores	Total cost Rs. crores.
1.	Fixed platforms in shallow water for crude production	6	1.5	9.0
2.	Fixed platforms in deep water for crude production.	25	5.0	125.0
3.	Single Buoy Mooring System for crude production.	2	2.0	4.0
4.	Submarine Pipe lines for crude Production.	380 KM	—	131.0
5.	Fixed platforms in shallow water for light houses.	10	1.5	15.0
6.	Single Buoy Mooring System for crude unloading.	1	2.0	2.0
7.	Submarine Pipeline for crude unloading.	10 KM	0.54/KM	5.4
8.	Single Buoy Mooring System for ore transportation.	1	2.0	2.0
9.	Submarine Pipeline for ore transportation.	1.6 KM	0.54/KM	8.6
10.	Imported equipment for fabrication & erection of above jobs.	—	—	27.0
11.	Indigenous equipment for fabrication and erection of above jobs.	—	—	2.0
12.	R & D Project.			3.1
13.	Miscellaneous.			5.9
				340.00

Foreign exchange component Rs. 270.0 crores.

In view of the economies that are possible consequent upon the development of offshore technology indigenously, it is necessary to develop a plan for operations over the next 10 years. As has been pointed out, if offshore technology is not generated indigenously in a phased and integrated manner, the country would have to pay a considerable amount of money in foreign exchange over the next 10 year period. For example, for a programme based on 10 million tons per year oil exploration and production target, the development of offshore technology indigenously can save the country about Rs. 270 crores in foreign exchange. If offshore terminals are developed, additional savings of the order of Rs. 20 crores per annum could be generated by use of very large crude carriers, which can be unloaded by deep water offshore oil terminals. Further, if the estimated shortfall of 30 million tonnes is to be met from offshore oil exploration & production, the savings would be three times as much as indicated above, i.e. about Rs. 900 crores. besides providing a substantial employment potential

Other Minerals

Mining of hard minerals from the sea bottom is still in its infancy, though surficial deposits from shallow coastal areas have been exploited in various parts of the world and in a limited way in India also. However, our present status of knowledge about the composition and structure of our shelves is extremely meagre and no reliable data exists to estimate the potential mineral wealth of our continental shelf. The following projects should be initiated for exploring our shelves, and for the use of sea water in non-conventional areas.

1. *Geological mapping and exploration* :—

A survey programme to obtain the basic knowledge of geology and mineral resources.

2. *Research on biogeneous and chemogenous marine deposits* :—

To establish the favourable environmental conditions for the occurance of various mineral deposits found on the sea floor.

3. **Offshore mineral technology development :**

Research and development work is required on special marine materials, sensors, mechanical and electrical systems, and life support activities, Design studies must be made for dredgers for sediment removal, mineral exploitation and for cutting trenches. Experimental studies are also required for recovery of minerals at varying depths.

4. **Sea water utilisation :**

R & D programme also need to be continued for the cultivation and utilisation of marine algal resources (sea weeds) and to assess the seawater tolerances for growing various food, fibre and cash crops by sea water irriculture.

IID. *The Coastal Zone*

The utilisation of our coastal zone for shipping, waste disposal and recreation is by any standards very limited. The problems affecting the optimum development of this zone are peculiar to our coasts and need to be solved by an accelerated programme of R & D work in the following areas :

1. **Development of ports :**

A number of R & D projects related to collection of marine data for coastal areas, new materials for harbour construction, development of marine fenders, floating breakwaters, dredging and offshore construction equipment etc. needs to be done. The research programme should also include an evaluation of marine forces on offshore structures and design of inexpensive shore protection and offshore facilities.

2. **Coastal pollution control :**

For selected stretches of the coastline, basic data should be collected and equipment designed to combat oil spills.

II E. *Technological capabilities development*

The basic components for developing the required marine technological capability are broad-based education and training programmes, information and data services, provision of support services at sea and an expanding instrumentation industry. Without these basic elements any efforts to explore and exploit the ocean would remain gravely handicapped and heavily dependent on foreign expertise :

1. **Education and Training :**

A programme for students in marine sciences and engineering are to be drawn up for providing them essential shipboard experience and training with modern and sophisticated instruments. Extension courses have to be arranged at selected centres for updating mid-career skills and re-orientation and transfer actross disciplines. A special fund also needs to be constituted for arranging demonstration and extension services for seabased industries and also for building the infrastructure and capabilities at selected marine education centres.

2. Information and data services :

For establishing appropriate and effective marine data collection, storage, processing and dissemination, it is important to set up a National Marine Data Centre. This centre will not only improve the coordination between user agencies by providing requisite data in standardised formats but shall be solely responsible for information management and distribution through publications, etc.

3. Support Services :

Services such as, mapping and charting of the oceans, testing facilities, safety, rescue and law enforcement on the sea are essential elements for expanding marine capabilities of the country. Another major gap in support services which needs to be filled is in instrumentation. Radio navigation chains must cover our entire costline and the areas of interest to India's marine industry. Facilities have also to be established for instrument testing, caibration and standardisation.

III. *INSTITUTIONAL-INFRASTRUCTURE*

There has been a multiplicity of organisations engaged in various fields of ocean sciences and engineering, but very little worthwhile progress has been made due to the absence of a coherent national plan of action and an effective agency looking after the marine interests and marine needs of the country. It has been the conviction of all those who have participated in preparation of the reports that India should make a national commitment to take the necessary steps to stimulate marine exploration, science, technology and financial investments on a vastly augmented scale. In the absence of an appropriate infrastructure, these efforts cannot be effectively launched and the following organisational requirements, become imperative.

1. The Oceans Science & Technology Agency (OSTA)

The objectives of the marine resources and management programmes recommended by the various planning groups and indicated above can only be achieved by creating a strong civil agency within the central government with adequate authority, resources and a broad mandate to advance a more effective use and better understanding of the total marine environment. The efforts till now have been on individualistic basis, poorly coordinated, and often half-hearted. It has become clear that a system relying upon coordination of organisationally dispersed activities, no matter how well administered, is not a substitute for a single operating organisation having authority and capability commensurate with the scope and urgency of the national marine resources and management programme.

2. An Offshore Design Engineering and Construction Organisation needs to be established to develop the indigenous technology in the fields of design, fabrication, and installation of various platforms, pipelines and storage facilities.

3. A national Marine Data Centre under OSTA or N.I.S.S.A.T. should be established for marine data collection, processing management and dissemination conforming to the overall framework of national plan for the advancement of marine technology and resources development.

4. A central Coast Commission/Committee is required to coordinate an integrated policy for the development and protection of the coastal zone and implement the policies.

5. A national Ocean Survey Agency should be established to maintain and operate the government owned multipurpose oceanographic survey fleets and provide the vessel and equipment services to any user organisation or carry out its own programmes as and when required by OSTA.

V. THE FINANCIAL COMMITMENTS REQUIRED

The financial commitments required for carrying out the programme enunciated above ve been worked out to be Rs. 32.25 crores. The details of the various projects are given the following pages.

It needs to be re-amphasised that marine resources and offshore technology are new areas d the existing institutional infrastructure are either weak or non-existent. While the investents in these areas are required on the ground of returns to the economy that may be expected, needs to be made clear that in the absence of the institutional changes recommended, the technogy investments here are unlikely to make other than marginal returns to the economy. It only through the creation of major marine agencies such as the proposed Oceans Science & echnology Agency and the adjunct organisations such as the proposed offshore Design ngineering Construction Organisation, National Marine Data Centre, Central Coast ommission, and National Ocean Surveys Agency that a truly national effort can be launched. e have recommended, due to fiscal constraints, that this effort be taken up on a modest scale day but that with the growth of the necessary organisations, an increase in the funding be llowed for. While reorganisation cannot be a substitute for new programmes, neither can rogrammes be launched in a new area of technology with maximum effectiveness through the xisting mechanisms. If our ocean and ocean resources are to be effectively utilised to yield he maximum returns to the economy, it is imperative that the necessary organisations are reated with adequate resources and formal authority.

The outlays proposed by the various groups are as indicated below :—

Group	Total (in Rs. lakh
1. Fish and Fisheries	793.
2. Environment	9.
3. Sea Water	106.
4. Marine Instruments	250.
5. Information (NISSAT)	
6. Education and Research	245.
7. Equipment	1000.
8. Minerals, Oil and gas	467.
9. Coastal Zone	354.
Total	3224.

The Project entering the S&T Plan for the Marine Resources Sectors are given below :—

Project Index No.	Title of the Project	Financial outlay (Rs. lakhs
1	2	3
	Fish & Fisheries	
$S_{17}G_1P_2$	Fisheries Research	793.
	Total G_1 :	793.
	Marine Environment	
$S_{17}G_2P_6$	Research projects concerning Marine Environment.	8.
A_3P_1	Wave forecasting and wave record analysis for selected Indian coastal areas. . .	1.
2	Studies of Chilka Lake.	0.
	Total G_2:	9.
	Sea Water	
$S_{17}G_3P_4$	Utilisation of Marine Algal Resources.	68.
5	Unit for basic research in marine plant physiology and ecology	7.
6	Sea Water Irriculture	16.
7	Stress Physiology under Sea Water Irriculture	5.
8	Soil Survey of Coastal Sand dunes and its relation to Sea Water Irriculture . .	7.
	Total G_3 :	106.
	Instruments	
$S_{17}G_4$ P_1	Geophysical Survey Instruments (Marine)	25.
2	Marine Instruments And Workshop Infrastructure	50.
3	Marine Meteorological Instruments and Data Bouys.	25.
4	Geological Survey Instruments (Marine)	25.
5	Geophysical Survey Instruments (Marine)	25.
6	Oceonographic Instruments	25.
7	Diving Techniques and Equipment	25.
8	Instruments for use in Fisheries.	50.
	Total G_4 :	250.

	2	3
	Information	
$7G_5P_1$	National Marine Data Centre	91.00*
	Education and Research	
$17G_6P_1$	Sea Grant Institutes.	95.00
2	Education, Training and Infrastructure Strengthening	35.00
3	Marine Operatives Training and Infrastructure Strengthening	95.00
4	Training for Marine Instrument Technicians	20.00
	Total G_6 :	245.00
	Equipment	
G_7P_1	RDD on Floating/Semi-Submersible/Submersible structures. . . .	100.00
2	RDD on Off-Shore Equipment and Structures (Engineering and Equipment Design)	400.00
3	Oceans Science and Technology Agency	500.00
	Total G_7:	1000.00
	Minerals, Oil and Gas	
tudies for offshore Oil and Gas		
$7G_8A_1P_1$	Sedimentological, Geo-chemical and Microbiofacies studies, in the continental shelf between Bombay High and offshore of Kutch including the Gulfs of Cambay and Kutch.	80.00
5	Sediment Transport Simulation	15.00
6	Oxygen Isotope study of the Foraminiferal tests of quarternary sediment along the Indian Coast and adjoining shelf areas.	24.00
7	Bubble Gas surveys Bombay High Areas	44.00
10	Geomorphological Evolution of Indian Coast	25.00
	Total G_8A_1 :	188.00
udies for offshore Minerals		
$G_3A_2P_6$	Experimental Study for Information on Heavy Mineral Placers . . .	0.36
7	Paleogeographic study for submerged Placer deposits.	0.64
	Total G_8A_2 :	1.00
ophysical Data Acquisition and Processing		
$G_3A_3P_1$	Close-Shore Backwater and Channel Survey. (Inland shallow water, rivers, Rann of Kutch, Deltaic Marshes)	60.50
5	Geotechnical and Petrophysical Studies	10.00
7	On Board Systems Software Development	20.00
8	Development of Application Software	25.00
	Total G_8A_3 :	115.50
rine Instruments (Survey)		
$G_8A_4P_2$	Seismic streamer Including Winch, Condep and Depth Indicator . . .	6.69
3	Marine Seismic Energy Source	12.28
4	Computer Based Seismic Recording System	24.30
5	Electro-Logging equipment	45.14
6	Digital auxiliaries for electro-logging and gravimetric equipment	12.33
	Total G_8A_4 :	100.74

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*This project has been transferred to the National Information System on Science and Technology (NISSAT)

1	2	3
Drilling and	*Production*	
$S_{17}G_8A_6P_8$	Synthesis of mud chemicals required for formulating sea-water mud . . .	32.
9	Synthesis of cement additives required for formulating sea-water slurries . . .	30.
	Total G_8A_6 :	62.
	Total G_8 :	467.
	Coastal Zone	
$S_{17}G_9P_3$	Oceanographic factors in beach erosion and accretion.	11.
6	Data collection, Interpretation and solutions against shore-erosion . . .	31.
7	Sediment movement and erosion of structures under wave action. . . .	4.
8	Study on rates of erosion and accretion.	18.
$S_{17}G_9P_9$	*Ports and Harbours*. . . . . (i) new materials for construction. (ii) metallurgical research for marine equipment ; high strength materials with anti-corrosive and antifouling properties. (iii) materials research, fibre reinforced plastics concrete, epoxy, etc. (iv) marine fendering. v) behaviour of structures under wave and wind action. (vi) development of floating breakwaters. (vii) dredging equipment methods and management. (viii) behaviour of ships at offshore moorings. (ix) propulsion methods for surface and sub-surface vessels. (x) underwater electrical systems. (xi) electronic equipment. (xii) programme evaluation for data collection and logging.	150.
$S_{17}G_9P_{10}$	*Pollution Control and Abatement* . . . . (i) influence of natural agents in cleaning coastal waters; meteorological and environmental study. (ii) research into assimilation and dispersal of maleffects by the ocean. (iii) thermal pollution and control.	40
$S_{17}G_9P_{11}$	*Erosion and Siltation* . . . . (i) theoretical anaylysis and prototype studies on the hydro-dynamics of beach and bottom sediment movement and the influence of waste disposal. (ii) sand by-passing systems and nourishment of an eroding coastline from offshore or other sources. (iii) study of mud-bank phenomena. (iv) studies with artificial seaweeds at select sites prone to severe erosion.	50
$S_{17}G_9P_{12}$	*Design of Coastal Structures* . . . . (i) studies on wave spectrums and wave heights with regard to structure designs. . (ii) evaluation of wave forces on standard coastal marine structures. (iii) dynamic response to wave forces. (iv) shore-protection works and artificial filters design and evaluation.	50
	Total G_9	354

SECTOR : METEOROLOGY

METEOROLOGY

Meteorology, the science of atmosphere, influences practically every facet of national economy. On a long term basis, the climate determines the natural vegetation, the abundance or lack of fresh water and the suitability of a given locality for any human activities. On a shorter time scale, the weather determines the best period for carrying out farming operations, the safety of different kinds of transport, optimum operation of a number of industries etc. Introduction of better methods of observation, use of more sophisticated instruments, quicker means of telecommunications,deployment of modern technologies like, electronic computer, rocket and satellite data, backed by better understanding of the atmospheric processes as a result of researches carried out, are the essential pre-requisites for better weather forecasts for aviation, shipping, agriculture, irrigation, railways, telegraphs, public works and health, flood control etc. All research work in this branch of science has long been carried out by the India Meteorological Department. With a view to provide more academic atmosphere for research in meteorology, an autonomous institute viz. Indian Institute of Tropical Meteorology (IITM) was set up in 1971. Amongst the educational institutions Andhra University alone has a specific course in Meteorology at the M.Sc. level. The Banaras Hindu University teaches Meteorology as a part of Geophysics. The contributions of the Physical Research Laboratory, Ahmedabad to the physics of the upper atmosphere including ozone, rocket and satellite meteorology are quite appreciable. R & D work in meteorology are also being carried out in the Indian Institute of Science, Bangalore; the Tata Institute of Fundamental Research, Bombay and Bhabha Atomic Research Centre, Trombay.

The IMD has developed considerable infrastructure, over its century of existence, for R&D, by reinforcing itself with latest techniques in radiosonde/radiowind station-network in the country and by organising Regional Meteorological Centre at New Delhi, for issuing prognostic charts on routine basis for the country and South-East Asian Region under 'World Weather Watch Programme' of the World Meteorological Organisation. The IMD has also set up a network of radar stations along the coasts of India for detection of tropical cyclones and ground receiving centres for satellite pictures in areas like space meteorology. The latest computer system IBM 360/44 is being set up at New Delhi for numerical weather prediction and other equipment like telecommunication computers are also being added under the programme of World Meteorological Organisation.

Although prediction of weather (short, medium or long range) is the primary objective of meteorology, the degree, type and nature of forecast vary widely depending on the users. This necessitates developing a number of techniques for forecasting weather. The application of these techniques depend on acquisition of accurate meteorological information both from land, sea and space. With the advance in technology, the methodology of data collection is getting more and more sophisticated and thus increasing the volume and accuracy of information. Sophistication in forecasting technique are also taking place all over the world to fit into it all such meteorological information.

In spite of the fact that a considerable amount of R&D work have already been put into different aspects of meteorology since long by the above institutions our knowledge is still far from perfection. Also, with the progress of all around development activities taking place in the country the nature of forecast and the degree of perfection are becoming more and more diversified. For instance, long range forecast have so long been issued for large areas of the country using statistical correlation technique but time has now come to develop techniques for forecasting rainfall probabilities for periods ranging from a fortnight to a season of four months ove small areas like district. This will be of great help in planning agricultural operations, wat resource management, flood control etc.

Again severe storms like Nor'wsters of Bengal (popularly known as 'Kalbaishaki'), seve dust-storms of North India and above all tropical cyclones of the Bay of Bengal and the Arabia Sea bring a considerable amount of damage to our lives and property every year. Assumi that mitigation of these natural hazards is beyond our capacity at present a timely warni about the occurrences of these phenomena will save much of our property. Many sophisticat weather observing tools e.g. radar, satellite available today are at the disposal of meteorologis Our age-old technique of predicting these weather phenomena are to be replaced by new techniques.

The physical conditions in stratosphere and mesosphere (16-85 kms.) influence the weath conditions and the dynamics, chemical reactions and energy transport thus become importa studies towards a safer civil aviation with the advent of supersonic jets. This has applicatio in weather forecasting and in defence. Similarly, the observation and critical analysis of t physical conditions in the lower atmosphere over the sea will have helpful applications in fishin defence, climatic studies and in navigation.

Global circulation system like monsoon plays a prominent role in our national econom Although general features of monsoon depression are understood, detailed structure of ea depression is still not known. In order to understand the genesis and decay of atmospheric syst and to forecast storm surge/tidal waves, studies on sea-air interaction are to be intensified.

The climate that prevails in the few meters above the earth surface affect man's life a his comforts. Urbanisation, agriculture and rapid industrialisation which necessitates cutting natural forests create a number of environmental problems closely connected with climatolo Newer disciplines like bioclimatology, urban climatology, building climatology, air pollut climatology have now emerged and it becomes necessary to study micro-climates of import regions and cities of India, so as to evaluate their influences on man and his survival. The ot R&D programme in tropical meteorology includes studies in snow-hydrology, hydro-meteorolo hail suppression, dissipation of fog at air ports, nucleation studies etc.

Droughts have become a constant feature in Indian economy, and it will be worthwh to try weather modification experiments by stimulating artificial rain by seeding of clouds chronically drought affected areas so as to minimise losses in agricultural income.

Studies are in progress in various aspects of micro-climate of crops, soil physics, pl physiology in relation to meteorological factors and crop-weather relationship. Locust propa tion over and near the western desert are dependent on meteorological factors. The agricult yield also depend on pests and diseases that grow in particular weather conditions.

Knowledge of solar radiation is necessary to understand the heat economy of the ea and various physical and biological processes taking place on this earth. Solar radiation sunshine data are useful towards a better understanding of relationship between weather solar radiation.

Design of instruments to measure condensation nuclei, ice forming nuclei, drop- distribution, liquid water content and precise temperature of the ambient air will greatly in studies in cloud physics and weather modification.

The NCST Panel on Meteorology which set up two sub-groups—one for Meteoro and the other for Tropical Meteorology, has identified a total of 53 projects for inclusion in S & T Plan. The total cost of R & D inputs for these projects comes to about Rs. 15.96 cr

The projects identified by the Panel are as under :—

SECTOR: METEOROLOGY

Project Index No.	Title of the Project	Financial Outlay (Rs. in lakhs)
1	2	3
	Meteorology	
$S_{11}G_1A_1$ P_1	Extended range forecasting	15.00
2	Numerical weather prediction	19.00
3	Data Processing	190.00
4	General Circulation Experiments.	10.00
5	Tropical Cyclone Research	390.00
6	Intensive study of monsoon depression and Meso-Scale phenomenon	65.80
7	Severe Storm Research	55.28
8	Upper Atmospheric Research	50.00
9	Marine Meteorology	9.50
10	Crop Weather relationship	125.00
11	Studies of pests and diseases in crops	8.00
12	Crop yield forecasting	21.00
13	Development of flood forecast techniques.	20.00
14	Water balance studies	8.59
15	Glaciological Studies	7.50
16	Atmospheric electricity, ozone,, radiation studies	96.90
17	Development of Navaid System	20.00
18	Development of Radar Technique	45.00
19	Studies of Atmospheric Pollution	12.00
20	Climatological studies:— (a) Compilation of climatological summaries for special uses. (b) Historic and plaeoclimatological studies. (c) Studies on solar radiation	10.50
21	Space Meteorology	75.00
22	Global Atmospheric Research Programme-Atmospheric Sciences & Marine Meteorology	56.00
	TOTAL G_1	1310.07

1	2	3
	Tropical Meteorology	
$S_{11}G_2P_1$	Numerical weather prediction (Dynamical approach)	12.0
	2 Medium and long-range forecasting (synoptic climatological and statistical approach)	8.0
	3 Ocean-atmosphere interaction	6.5
	4 Storm Surge/tidal waves forecasting	2.7
	5 Satellite input to analysis and prediction	2.1
	6 Objective analysis of meteorological fields	4.6
	7 Studies on severe local storms	2.5
	8 Monsoon and tropical circulation including simulation experiments	3.9
	9 Tropical cyclone research	7.2
	10 Secular changes in meteorological elements over India	1.9
	11 Synoptic and dynamical climatology	5.0
	12 Micro and bio-climatology	2.3
	13 Development of machine methods for analysis of intense rainstorms	3.4
	14 Studies on snow hydrology	5.0
	15 Inducement of artificial rain and dissipation of fog, nucleation studies	40.0
	16 Experiment in hail suppression and hail measurement	30.0
	17 The inter-level relationships between phenomena of the propesphere, stratosphere and the mesosphere and their influence on the Asian Summer monsoon.	7.0
	18 Role of cloud electrification in rain developemnt	4.2
	19 Radiative properties of the atmospheric constituents, including aerosols in the short and long wave regions and their role on the heat balance of the earth-atmosphere system in the tropics.	6.8
	20 Effects of air pollution on rainfall and climate	4.0
	21 Basic studies on clouds and precipitation using radar	32.2
	22 Design and fabrication of infra-red meteorological instruments for remote sensing	3.9
	23 Investigation on exchange processes in the atmospheric boundary layer	10.0
	24 Development of instruments for incloud measurements	4.0
	25 Theoretical studies of general circulation with special reference to Indian monsoon	5.3
	26 Theoretical studies of the oscillations of the tropical atmosphere	4.7
	27 Study of dynamic instability	1.5
	28 Theoretical study of meso-scale phenomena	0.8
	29 Modernisation of computer facility at IITM	56.7
	30 Laboratory experiments in fluid dynamics	4.0
	31 Study of meso-scale phenomena at Visakhapatnam	2.8
	TOTAL G_2	285.

HIGHLIGHTS OF IMPORTANT R & D PROGRAMMES

. *Numerical weather prediction.*

Numerical weather prediction is a new technique developed in the advanced countries for ie forecast of weather maps 24 hours ahead, using electronic computer. Under a scheme of the /orld Weather Watch Project (WWW) of the World Meteorological Organisation a Regional leteorological Centre has been established at New Delhi which is responsible for issuing prognostic harts on a routine basis for the country and also for the South-east Asia including Indian)cean. India Meteorological Department and the Indian Institute of Tropical Meteorology have een conducting researches in this field for nearly 5 years and both these institutions have developed arious models for the prediction of flow pattern 24—48 hours ahead for extending rain orecast. The IITM already possesses a computer and KMD is shortly acquiring a computer or this purpose. Both these institutions will develop their models further to provide the ser interests more reliable weather forecasts.

. *General Circulation Experiments.*

Monsoon is the most important factor to be reckoned with in regard to weather over the ndian sub-continent about which quite a few problems have not yet been understood. It is, thereore, necessary that studies are made on general circulation over the tropics to study the basic ehaviour of the atmosphere in this region. Attempts will be made to stimulate monsoon circulaion by numerical methods to understand the importance of various interactions taking place therein vhich will help in improving the quality of forecasts.

3. *Tropical Cyclone Research.*

Researches into tropical cyclones have been conducted in the country since long but three ecent developments have revolutionised our knowledge in this field—meteorological radar, meteorological satellite and meteorological aircraft reconnaissance. Under the projects it has been envisaged that a chain of radars will be installed in east and west coast for tracking the cyclones, and a four engined aircraft, Doppler Navigational radar, aircraft met-instruments and a minicomputer will be utilised.

4. *Severe Storm Research.*

R&D activities on the Nor'westers of Bengal and dust-storms of north India have been carried out since long with the aid of data collected mostly from ground based observatories including radar. The group has identified gaps in our knowledge of the actual structure of these storms which could only be observed from aloft. It has been envisaged that aircraft reconnaissance of the storm would be undertaken to know more about the storm and improve upon the existing technique of forecasting their occurrence, their intensity and movement.

5. *Research in Atmospheric Sciences.*

The physical conditions in the stratosphere and mesosphere play an important role in influencing the weather conditions. Presently, not much R&D work in this field has been done in the country. Under the projects it has been suggested to conduct extensive investigation to study the dynamics, chemical reactions and the energy transport; coupling between troposphere and stratosphere and between stratosphere and above; and also the ozone variations with wind and temperature and their influences on the surface weather. Besides taking upper air observation with balloon borne instruments regular firing of rockets with meteorological payload has also been envisaged.

6. *Agricultural Meteorology.*

Under the scheme three separate projects have been suggested. They are (a) crop-weather relationship (b) pests and diseases in crops and (c) crop-yielding forecasting. Various aspects of micro-climate of crops, soil-physics, plant physiology in relation to meteorological factors and crop-weather relationship have been studied to some extent. Crop weather calendars depicting the details of weather effecting individual crops and the nature of warning required for each crop have been compiled. Formulae have been evolved to forecast the yield of wheat and rice in different localities based on weather parameters. Under the projects further studies will be made on the growth and behaviour of plant under artificially produced weather conditions in control chambers. Also studies will be made on weather conditions leading to growth of pests and disease in crops for evolving suitable criteria for warning. For this purpose special agro-meteorologica instruments will be developed.

7. *Development of Flood forecasting technique.*

The existing techniques of flood forecasting needs to be refined taking into account actua and expected rainfall in the various river catchments. One of the important components of th scheme is to develop and improve methods of issuing qualitative precipitation forecast and unde taking studies in relating rainfall to run off; use of radar in observations and forecasting of pre cipitation and application of satellite pictures to hydrological problems.

8. *Glaciological Studies.*

Estimation of snow accumulation during winter months and contribution of snow melt t river flow especially during summer months are important from consideration of reservoir oper tions of Himalayan rivers. Ice piles over the Himalayas are now being monitored with th aid of meteorological satellites. Under the project improved technique of interpreting satelli pictures has to be evolved to make quantitative estimation of snow cover, snow line, snow-me contribution to river flow etc.

9. *Artificial rain making experiments.*

Rain Research Unit of the NPL developed technique of stimulating clouds by seedi common salt from ground based generators. A series of experiments were conducted in ea sixties over Delhi-Agra-Jaipur and claimed success in increasing rainfall by 20 per cent in th sector. Since 1966 onwards the R&D activities in this field slowed down due to lack of certa facilities. Presently, new technique of dynamic cumulus modification has been developed advanced countries, like USA, USSR, Canada. Since drought have become a constant featu in Indian economy, it will be worthwhile to try weather modification experiments for stimul ing rain artificially by seeding clouds in chronically drought affected areas.

SECTOR--FUEL & POWER

FUEL AND POWER

The world energy crisis and the effect of our present power famine affecting the lives of millions of farmers, factory workers and ordinary consumers needs no elaboration. The present installed generating capacity of about 18 million KW is expected to rise to 35 million KW by the end of Vth Plan. This growth of installed generating capacity together with inter-connection of power systems would require considerable R & D efforts in power supply industry and electrical manufacturing industry. Presently the expenditure on R & D is grossly inadequate at about Rs. 8 crores per year (approximately Rs. 20 crores in the whole of the IVth Plan) to achieve maximum utilisation of the existing total investment of about Rs. 5600 crores in the power sector already made in the past, and a further outlay of about Rs. 6200 crores proposed during the Vth Plan. Considering the average value of about Rs. 500 crores per year for the sale of power and about Rs. 550 crores per year for the production sale value of electrical machinery and equipment manufactured the present level of R & D activities is totally inadequate. As a result, there is almost total dependence on foreign collaborations for any substantially new designs of equipment. Improvments in existing equipment, remedial steps in their discovered faults, or increase in their reliability of service etc. which results from R & D activities, is non-existent. The installed capacities are therefore yielding no more than 40% output which is a great national loss causing severe constraints on capital resources.

To remedy these conditions, it is recommended that the R & D activities and outlay in the fuel and power sector in the Vth Plan should be about Rs. 180 crores, most of it against well identified projects with defined mechanism and defined time frames. This will speedily build indigenous technology which will enable the electrical industry to grow on its own technical capability Vth Plan onwards and restrict imported know-how to critical technological gaps only.

It is estimated that the proposed outlay of Rs. 180 crores in the Vth Plan on the fuel and power sector would require about 3000 additional trained R & D staff at 4 levels, (a) R & D managers (b) senior/middle level R & D personnel (c) fresh R & D staff and (d) skilled/semi-skilled technicians. Out of these about 1000 would need to be engineers/scientists with degree and higher qualifications. The foreign exchange component of the R & D outlays is estimated at approx. Rs. 20 crores.

The Fuel & Power panel of the NCST by associating about 150 scientists and technologists has identified about 50 R & D projects for implementation during the Vth Plan.

Detailed reports have already been prepared by the panel on fuel and power :—

1. R & D Relating to Electrical Industry and Power Systems.
2. Magneto-Hydro-Dynamics (MHD) Power Generation
3. Institute for Energy Studies/Planning
4. Solar Energy
5. Tidal Power
6. Wind Power
7. Chemical Energy Sources
8. Aero Gas-Turbines for Power Generation

9. Coal Utilisation for Import Substitution
10. R & D to Improve Utilisation of Existing Thermal Stations
11. Pattern of Energy Demand and Consumption in the City of Bombay.

As a result of this project oriented R & D plan in the fuel and power sector, necessary competence will be generated amongst 3500 engineers, scientists and technical staff to launch upon the VI and subsequent plans and these will form the nuclei for further development of a still greater magnitude that the fuel & power fields will call for. Indian technology in these fields will by the end of the Vth Plan begin to command world respect, enabling India to enter upon export of goods and technologies, besides the most important gain—increase of efficiencies from existing capital investments, improvement in quality and reliability of the Rs. 12,000 crore fuel & power base which is suffering a great set back presently for lack of internal technological support.

Under the Fuel and Power Panel 13 Planning Groups were set up to identify and recommend R & D activities which would assist in meeting the Vth Plan targets and make the country self-reliant in this field. The recommendations of the Planning Groups are summarised in brief below:

1—*Joint Planning Commission—NCST Task Force on R & D for Power Development*

This Task Force has noted that the existing infrastructure for R & D in the power suppl and equipment sector is inadequate. The Task Force, has, therefore, recommended that some major product development, research and materials development projects should be undertaken or a national basis to reduce dependence on imported technology/materials. In addition to expansion of existing R & D facilities, the setting up of some new centres/laboratories is also envisaged. The major projects identified include 500 MW proto-type unit, high voltage AC and DC experimental transmission lines and steam turbine development centre. The setting up of centres fo training power systems personnel and a Power Technology Development Board are also recommended.

2—*Magneto Hydro Dynamics (MHD)*

A study team comprising specialists was constituted to assess to the state of MHD technology and make specific recommendations regarding initiating suitable programmes in the country The study team has submitted a detailed report which recommends initiating coal based laboratory scale experiments at the level of 2 to 5 MW for developing necessary scientific/technological skills in the country. The results of these lab-scale experiments would be reviewed to enabl a decision to be taken on the 25 MW proto-type. A detailed project report for initiating lab scale experiments has been prepared.

The MHD plant in combination with conventional steam turbine plants would be able t reach efficiencies of the order of 50%, thereby enabling better utilisation of the country's co resources. If the trials prove successful, a 1000 MW MHD station would consume 1 millio tonnes of coal less per annum than a conventional thermal power station.

3—*Fuel Efficiency*

The average efficiency of fuel utilisation at present is low and savings of about 20% ma be feasible through R & D efforts. Although 70 million tonnes of coal is raised, the saving could be in sectors utilising roughly 40 million tonnes. It is recommended that fuel efficienc services in the country need to be strengthened, and may have to be provided on a subsidise basis to the small scale industrial sector using fuel oil which is largely imported now. The ack of trained personnel for operation of boilers and furnace is another area requiring immediate attention. Courses for training boiler operators need to be organised at regular intervals. Initially six training schools, three for industrial sector and 3 for power sector are recommended. It has also been estimated that with the same fuel consumption about 10 MW of incidental power can be generated by each of the bigger industrial units who require power and steam for process needs, if they generate steam at higher pressure and are permitted to have a captive power plant with the exhaust being utilised to meet process steam requirements.

4—*Institute for Energy Studies/Planning*

The Energy Survey Committee of India in 1965 and the Fuel Policy Committee in 1972 have recommended the setting up of a full time institute for carrying out energy studies on a continuing basis. The almost exponential growth in energy consumption, together with changes and shifts in pattern of inter-fuel substitution has focussed the urgency for forecasting future growth trends, both of energy supply and energy demand, particularly keeping in view the country's meagre resources and the growing vast population. A conceptual framework for the setting up of such an institute has been drawn up. The UN has also recommended the setting up of National Energy Institutes in member countries.

5—*Solar Energy*

A detailed exercise on why solar devices have not found popular application is currently under way. R & D towards some promising areas of application, such as drying and storage of grain, water, heating, ice making, refrigeration, desalination and distillation are recommended. Work on solar energy so far has been diffused and of sub-critical nature scattered at several laboratories in the country. The setting up of a separate Solar Energy Laboratory is recommended to undertake intensive R & D programmes and provide technical back-up necessary to popularise promising areas of application, since solar energy is recognised as a non-depleting and non-polluting energy which India receives very abundantly.

6—*Tidal Power*

Coastal regions in the country where some R & D work on harnessing tidal power could be considered have been broadly identified. The CWPC has proposed UNDP funding to carry out, at this stage, only further studies and prepare feasibility reports with regard to specific coastal locations. These reports would indicate whether the setting up of experimental R & D units could be considered.

7—*Wind Power*

The wind data from over 400 Meteorological Stations has been analysed and it has been assessed that there are some regions in the country where wind mills for water pumping and electric power generation can be utilised with advantage. A proposal has been drawn up for installing wind mills in cluster for pumping and power generation applications. Wind mills in conjunction with storage batteries appear promising for rural electrification application. Another proposal envisages indigenous manufacture of 5 to 10 KW wind electric generators based on foreign designs already available in the country for use in remote areas away from conventional power houses.

8—*Geothermal Energy*

Whilst exploration efforts by GSI, NGRI and CWPC (under UNDP) are being enhanced, it is recommended that some R & D on utilisation of geothermal energy in promising area of application should also be simultaneously initiated. Central heating system in Ladakh and refrigeration system in Manikaran hold considerable promise. It would be worthwhile to put up a small 5 to 10 MW steam turbine for trials at one of the drilling locations. The CWPC has envisaged UNDP assistance in this field.

9—*Chemical Energy*

In order to reduce consumption of motor spirit and HSDO, the development of a light battery powered vehicle is recommended for commercial and domestic applications. This project can only be successful if all the latest technological advances are adopted, rather than mere replacement of the existing petrol engine by an electric power pack. The success of this project could also lead to consideration of heavier vehicles for mass-communication purposes in urban centres.

Another project utilising fuel cells for rural electrification has been identified particularly for villages having a population of 500 and below. At present only about 12% of all such villages have the benefit of electricity. The successful implementation of this project could reduce kerosene demands in the rural sector as well as lead to some reduction in consumption of non-commercial energy sources. The development of more sophisticated and advanced fuel cells for the above two specific applications is also recommended.

10—*Utilisation of Surplus Aero-Gas Turbines for Power Generation*

Gas turbines are attractive for meeting peak load and emergency power requirements. Fur thermore, dual gas-*cum*-steam turbine cycles enable fuel efficiencies of over 50% to be achieved thereby enabling higher utilisation of the country's coal resources. The IAF is due to phase ou several engines from service, which can be used for power generation, provided R & D is starte immediately. Four surplus aero engines have recently been imported from U.K. to initiate R & work in the country. The R & D effort involves the setting up of 2 aero-gas turbine sets eac of 10 MW capacity. R & D on gasification of coal as an alternative fuel is also recommended Eventually, about 200 engines may be retired within the Vth and VIth Plan periods, and if utilise power would be generated at an estimated capital cost which is half of the conventional therma power generation.

11—*Coal Utilisation for Import Substitution*

In view of growing dependence on oil product such as kerosene, LPG etc. and on no commercial fuels, the setting up of two low-temperature carbonisation plants is recommended; o plant to be located in the Bengal-Bihar area based on CFRI process and one plant in the Godava Valley based on RRL Hyderabad process.

The setting up of a prototype coal-to-oil plant capable of producing half to one million tonn of middle distillates per year is also recommended in view of the increasing import bill on petr leum products. As coal is the only source of energy abundantly available in the country, R & efforts to ensure its best utilisation are warranted.

12—*R & D for Better Utilisation of Thermal Stations.*

It has been noted that thermal stations in the country have an average utilisation factor about 40 %. This poor performance has necessitated provision of generating capacity with a w and uneconomic margin. It is, therefore, recommended that efforts should be made to assess w R & D activities must be undertaken which could lead to better utilisation of existing thern stations. Preliminary visits to three stations has indicated the necessity of taking up mate development programmes to substitute imported spares.

It is proposed to visit about 15 major stations to identify common problem areas towards which R & D would need to be directed at appropriate research laboratories.

13—*Coal Slurry Pipeline*

Transportation of coal slurry by pipeline is an attractive alternative mode of transportation particularly for distant bulk consumers. At present technological competence for coal slurry pipeline does not exist in the country. The Fuel Policy Committee has recommeded developing technological competence in this area. In the first instance a feasibility report on the setting up of a prototype pipeline from a particular mine to a specific user would be prepared. This report would enable an investment decision to be taken on the setting up of prototype pipeline.

The outlays recommended by the various groups are as under

No.	GROUP	Financial Outlay (Rs. lakhs)
1	2	3
	R & D relating to Electrical Industry and Power Systems	15,000
	M H D	700
	Fuel Efficiency	180
	Institute for Energy Studies/Planning	150
	Solar Energy	250
	Tidal Power	2
	Wind Power	16
	Geothermal Energy	20
	Chemical Energy	47
	Aero Gas Turbines for Power Generation	900
	Coal Utilisation	1,000
	Better Utilisation of Existing Thermal Stations	24
	Coal Slurry Pipe Line (Included in Transportation Sector)	
	Total	18,289

The Projects identified by the groups are given below

Project Index No.	Title of the Project	Financial Outlay (Rs. lakhs) Total
1	2	3
	G$_1$ R & D Task Force	
$S_3G_1P_1$	500 MW Prototype	8,000
2	R & D Projects—Power Systems	200
	(a) 400 kv line and equipment	100
	(b) H.V. D.C. line and equipment	300
	(c) Misc. generation, transmission, distribution	400
3	R & D facilities—Expansion—New	
	(a) Ultra H.V., synthetic testing, training of power system and maintenance engineers	1,000
	(b) Steam turbine dev. centre, superconducting, Dev. Centre for small & medium scale industries, On line computation/automation, direct energy conversion	500
4	Product Development Projects Large transformers, super conducting motors, Bulb turbines	1000
5	Material Development Programmes Creepresist steels, non-ferrous, insulations, special alloys, ceramics, new materials	1500
6	Power & Industrial Electronics Process control, automation, instrumentation, computers	700
7	Regional Research Facilities, State Electricity Boards, Research Units	600
8	Long Term R&D Projects	600
9	Power Technology Development Board	100
	TOTAL	15,000
	G$_2$ MHD	
$S_3G_2P_1$	MHD 2-5 MW Laboratory Scale experiments	700
	Total	700
	G$_3$—Fuel Efficiency	
$S_3G_3P_1$	Fuel Efficiency Services	30
2	Efficient Fuel Oil Burning equipment	20
3	Antipollution equipment	20
4	Waste Heat Boilers (Fuel Efficiency)	50
5	School for Boiler Operators	30
6	Total Energy Concept Studies	5
7	Anticorrosion & Tribology Services	25
	Total	180
	G$_4$—Institute for Energy Studies/Planning	
$S_3G_4P_1$	Institute for Energy Studies	150
	Total	150

1	2	3
	G_5—Solar Energy	
$S_3G_5P_1$	Laboratory for Solar Energy	120
2	Solar Cells	20
3	Solar Distillation	20
4	Solar Drying	20
5	Solar Cookers	10
6	Solar Water Heaters	10
7	Solar Space Heating, Cooling, Refrigeration and Ice Making Machine	50
	Total	250
	G_6—Tidal Power	
$_3G_6P_1$	Studies on Pilot Plant for West Coast	1
2	Studies on Pilot Plant for East Coast	1
	Total	2
	G_7—Wind Power	
$_3G_7P_1$	Wind Mill for Power Generation	5.0
2	O & M services	1.0
3	Wind Mill for Pumping Water	7.0
4	Collection of Wind Data from IMD on Computor	0.5
5	Report on 5-10 KW Wind Generator (Consultant)	2.0
6	Steering Committee on Wind Mills	0.5
	Total	16.00
	G_8—Geothermal	
$_3G_8P_1$	Geothermal Energy Utilisation—Studies—Experiments	20
	Total	20
	G_9—Chemical Energy Sources	
$_3G_9P_1$	Battery Powered Vehicle	15
2	Long term R & D projects	
	1. Lithium Cells	
	2. Sodium Sulphur Cells	4
	3. Metal-Air Cells	6
	4. H_2—O_2 Cells	5
3	Steering Committee for Above Projects	5
4	Development Board for Chemical Energy Sources	5
	Total	47
	G_{10}—Gas Turbine	
$_3G_{10}P_1$	10 MW Peak Load Project	100
2	10 MW Base Load Project	250
3	Waste Heat Boiler (for Gas Turbine)	400
4	R&D on Use of Coal gasification for Gas Turbine	130
5	Preliminary 150 MW Dual Cycle Plant Work	200
	Total	900

1	2	3
	G_{11}—Coal Utilisation	
$S_3G_{11}P_1$	Survey of Fuel Consumption in Bombay (Work Already Completed)	(2)
2	R & D for LTC Plants	
	(a) Bengal Bihar area	250
	(b) Godavri Valley	250
3	R & D for Coal-to-Oil Plant	500
	Total	1000
	G_{12}—Better Utilisation of Existing Thermal Stations	
$S_3G_{12}P_1$	R & D to Improve Utilisation of Existing Thermal Stations—visits, diagnosis, 'workshop' meeting	2
	Total	2
	G_{13}—Coal Slurry Pipe Line	
$S_3G_{13}P_1$	Coal Slurry Pipe Line feasibility report } Included in Transportation Sector.	—
2	Prototype experiments	
		—

HIGHLIGHTS OF IMPORTANT PROJECTS

rototype 500 MW unit

A joint Planning Commission-NCST Task Force on Research & Development in Electrical ndustry has in its report recommended that design, development and manufacture of 500 MW hermal generating plant be undertaken during the Vth Plan. This R & D project would compre- ndustry has in its report recommended that design, development and manufacture of 500 MW nanner. Separate development programmes for individual components for 500 MW would equire more time, money and manpower. The organisational responsibility for this project vill be with BHEL, who have already prepared an interim report. The final project report is nder preparation.

BHEL propose to develop the design through indigenous efforts and the existing know-how n suspect of 110/120/200 MW thermal sets, for steam generating equipment, boiler house uxiliaries, condenser, heaters and the turbo-alternator. In specific areas of steam turbine, boiler eed pumps, instrumentation and control, technological capability has to be built up. Wherever xpertise, test facilities or even process know-how does not exist, foreign assistance will be sought o the extent necessary in keeping with the cost and time-frame. The approximate estimate for 500 MW unit is envisaged to be about Rs. 80 crores (Rs. 8 crores for R & D and Rs. 72 crores or prototype equipment). Experience gained in the design, development, setting up and operaion of the 500 MW unit would enable its commercial application in the VIth Plan period.

& D Projects—Power Systems

Important projects identified include 400 kv line and equipment, high voltage DC line and quipment and several smaller R & D projects under generation, transmission and distribution.

At present design data available in the country relates to a maximum voltage of 220 kv class n the power supply as well as electrical manufacturing industry. On present indications, manuacturers appear to be arranging collaborations for import of know-how for the manufacture of ower transformers, instrument transformers and other terminal equipment. In spite of these rangements, there will still be technological gaps in the design data of equipment. Also some ndigenous work will be necessary in the design and construction aspects of 400 kv lines. It vould be desirable for the 400 kv activities to be designed so as to give guidelines for the deveopment of higher AC systems. Similarly, work on high voltage DC power supply and electrical nanufacturing industry needs to be undertaken during the Vth Plan. The setting up of an xperimental high voltage DC line is recommended.

The total outlay involved for such R&D projects in the power supply sector amounts to Rs. 10 crores—Rs. 7 crores to be funded and monitored by CPRI (Ministry of Irrigation & Power) nd Rs. 3 crores by BHEL/RDOEI (Min. of Heavy Industry).

Expansion of R & D facilities

At present R & D facilities in the fuel and power sector exist at (a) Research Institutes—CPRI, RDOEI, NTH, CWPRS, CSIR Labs, BARC, etc. (b) Educational Institutes—IITs, IISc, Universities, Colleges, etc. (c) Public Sector Industries—BHEL, HEIL, HEC, HSL, etc.—(d) Private Sector—Jyotis, Kirloskar, Larsen & Toubro, Tatas, etc. and (e) State Electricity Boards—Co-ordinated/funded by CBIP.

Four teams have visited and assessed many of these facilities. In the light of the identified R & D tasks to be undertaken during the Vth Plan, strengthening of existing facilities is recommended not only to fully utilise the existing infrastructure, but also to get quick meaningful results. Additional R & D facilities may also need to be set up for such areas of work as direct energy oonversion, UHV testing and development, synthetic testing for circuit breakers, integrated operation of power systems, maintenance, steam turbine development, large electric machines, super conducting electrical equipment, etc. Specific proposals for R & D facilities involving a total outlay of Rs. 15 crores have been worked out—Rs. 10 crores for work to be funded and monitored by CPRI (Min. of Irrigation & Power) and Rs. 5 crores by BHEL/RDOEI (Min. of Heavy Industry).

Product Development Projects

It is forecast that large furnace and rectifire transformers of 25—50 MVA ratings will be required during the Vth Plan for such industries as aluminium, electro-chemical etc. Bigger traction transformers for more powerful locomotives, shunt rectifires and static capacitors for voltage regulation of long transmission lines, aluminium wound transformers, reactors and instrument transformers etc. are also required to be developed.

The use of super-conducting materials for motors is another promising area for which R & D needs be initiated. As the probability of application of super conducting DC motors is the highest, a project to develop a 1000 HP, 600 RPM motor has been drawn up. Work on super conducting materials would also find application in naval craft, super magnets for MHD & fusion research and very high speed traction.

A project for the development of bulb turbines suitable for micro hydel and tidal power generation has also been identified.

The total outlay proposed for the above product development projects amounts to Rs. 10 crores—Rs. 5 crores to be funded and monitored by the Min. of Irrigation and Power and Rs. 5 crores by the Min. of Heavy Industry.

Materials Development Programme

The electrical manufacturing industry requires diverse types of materials such as copper conductors, stampings, CRGO sheets steel, insulations, alloy steels, non-ferrous, welding consumables, ceramics etc. A materials development programme to meet the critical needs of the electrical industry has been drawn up which would have to be sponsored and monitored by Ministries of I & P and Heavy Industry (users) on a collaborative basis in academic institutions, national laboratories, (NML, CECRI, BARC etc.), manufacturers (HEC, HSL, etc.). In addition, some components, such as forgings, castings, spares, valves, devices for instrumentation and contro etc. have also been identified for indigenous development. An outlay of Rs. 15 crores would be required for the materials development programme, Rs. 7.5 crores to be sponsored by the min. of I & P and Rs. 7.5 crores by the Min. of Heavy Industry.

Power & Industrial Electronics

R & D on DC operated electric drives, which are now in extensive universal use, needs be taken up indigenously. Whilst, certain collaboration arrangements are being arranged to impor the know-how on thyristor technology, there is need for indigenous R & D, as the innumerabl variations and combinations cannot be covered by any single collaboration. In addition, indigenisation of components would also be necessary. Research laboratories, educational institutions an manufacturers can collaborate for R & D in this field.

The use of invertors and cyclo-convertors is also likely to increase within the next few years nd will enable introduction of AC motors because they are cheaper and more sturdy. AC motor ntrol, particularly of squirrel cage induction motors, could find application for electric comotives. Consequently, R & D for invertors is necessary to be carried out at education stitutions and laboratories.

With time, the extent of process control and automation control would increase. For instnce, the 500 MW programme would necessitate the use of process control and automation techques for operating such large units. The areas of application on process control and automation e very varied and, therefore, research, design and development activities have to be taken up uring the Vth Plan. The R & D activities in this field involving an outlay of Rs. 7 crores recommended to be funded and monitored by the CPRI (Min. of Irrigation & Power).

ate Electricity Boards and Regional Research Facilities

Various Electricity Boards have research centres, which are being awarded projects by e CBIP (Ministry of Irrigation and Power). Much of their present work is connected with utine O&M problems faced by the Electricity Boards. In addition, they also act as field entres for distribution and collection of data. On the other hand, the national institutes such s CPRI are generally engaged on areas of advance technology and analytical work relating power systems. Thus, there exists a gap in the organisation of R & D, particularly to cater the operation, maintenance and training problems of regional grids. It is, therefore, recomended that not only should the CBIP funded research at Electricity Boards be strengthened nd enhanced to the extent feasible, but in addition, Regional Research Institutes be established ithin the control of Regional Electricity Boards for tackling problems pertaining to operations, aintenance, construction, etc. It is recommended that an outlay of Rs. 6 crores be made vailable to the Ministry of Irrigation and Power for this work.

ong Term R & D Project

Whilst the basic thrust of the R&D plan for the power sector would necessarily be on th and VIth Plan investment projects, it is important that programmes for long term research re also initiated during the Vth Plan itself. It is, therefore, recommended that about 5% f the proposed R&D outlay on the power sector be devoted to such long term research projects. is recommended that an outlay of Rs. 6 crores be made available to the Ministry of Irrigation nd Power for funding and monitoring such projects.

ower Technology Development Board

It is recommended that a Power Technology Development Board (PTDB) be set up which ould be charged with responsibilities of accelerating, expanding and co-ordinating the national fort of technological development for power systems and equipment. The R&D activities at resent span a vast range of the inter related programmes dispersed over at least half a dozen ational institutes, scores of field stations and many manufacturers' R&D centres. The present vel of annual expenditure of the order of Rs. 8 crores would nearly treble over the next five ears. There is thus a need for a 'national' outlook on all R&D for power development. The roposed PTDB would be responsible for spearheading concerted, coordinated and integrated pproach to the S&T requirements. The PTDB could have powers and be functionally organised n the lines of the Electronics Commission or the Atomic Energy Commission.

IHD Programme

The MHD programme has been recommended on the basis of technology development in ther countries and existing resources in our country. The overall efficiencies of the order of 50% for MHD-Steam plants have been estimated even from laboratory studies and higher efficiencies are envisaged from the advanced technology. The MHD power process is fre from environmental, thermal and radioactive pollution. The MHD technology when develope would enable better utilisation of the coal resources for power generation.

A detailed report on MHD power generation has already been submitted to the Plannin Commission by Bhabha Atomic Research Centre. The NCST has recommended tha development work on laboratory scale at 2—5 MW level be initiated based on coal gasificatio technology. The results of these experiments would be reviewed before a decision on 25 M can be taken.

The financial outlay for the initial laboratory scale experiments would be Rs. 7 crores comprising Rs. 2 crores by BARC on plasma physics, duct materials etc. Rs. 0.5 crores by CSIR on coal gasification and Rs. 4.5 crores by BHEL/HEIL on magnet, combustors, stea generator, etc.

Efficient Fuel Oil Burning Equipment

To enable greater fuel economics in oil fired burners to be achieved, work on efficien oil burning equipment such as low excess air burners, oil gasification, etc. would be necessar The IIP has the necessary expertise and equipment to take up this work. The Nationa Productivity Council as consultants on fuel efficiency has identified specific problems in o combustion in industry which require to be solved by IIP.

Anti-pollution Equipment

The development of anti-pollution equipment, particularly for specialised application suc as operation at high temperature etc., has been identified to specifically meet the requiremen of industrial and power boilers/furnaces. As BHEL is already engaged on R&D in this are the development of other specialised anti-pollution equipment can also be undertaken by then To start with, a survey of actual operational efficiencies of existing equipment will have to b undertaken, as efficiencies much lower than design values have been reported. Suitable ant pollution devices for automobile exhausts also require to be developed.

Waste Heat Boilers

There is considerable scope for recovery of waste heat from general process industries such as steel plants, fertiliser plants etc. Installation of waste heat recovery systems lik recuperators, regenerators, boilers, etc., wherever feasible, should be encouraged and popularise This measure would lead to reduction in loss of waste heat through the chimney to th atmosphere, and much of it could be recovered easily, resulting in fuel savings of the order o 10-30%. Evolution of suitable designs of waste heat boilers by boiler manufacturers necessary. Suitable designs of municipal incinerators, which could also generate by product lo pressure steam, also require to be developed.

Fuel Efficiency Services

The average efficiency of fuel utilisation at present is low and large savings of the order o about 20 per cent may be feasible through R&D efforts. Inefficient fuel utilisation also leads increasing atmospheric pollution. The Fuel Policy Committee and the NCST have recommende that fuel efficiency services must be enhanced and be made available to larger number of cons mers. For small and medium scale industries, using boilers/furnances, such services may hav to be provided on a subsidised basis. The National Productivity Council has been identified the implementing agency for providing such services.

etting up of Regional Training Schools for Power/Industrial Boiler/Furnace Operators.

One of the major factors responsible for inefficient utilisation of fuel is the lack of trained ersonnel for operating boilers and furnaces. At present the examination for the certificate of ompetency for boiler attendants is conducted by the Boiler Examiners for Boiler Attendants. Except the training scheme of the Directorate General of Apprentice Training, Ministry of Labour, there is no planned training schemes for boiler attendants at national level. There are ome training schemes for boiler attendants within certain industries, but this does not meet fully he requirements from the fuel efficiency angle. The NCST has recommended that courses for raining boilers operators be organised at regular intervals by the National Productivity Council (NPC). A suitable fee could be charged by NPC for organising above mentioned training. In egard to small & medium scale sectors, such training may have to be provided on a subsidised basis. Initially 6 training schools, 3 for industrial boilers and 3 for power boilers, are proposed o be established.

Total Energy Concept

There is considerable scope for fuel economies, if process industries, such as fertilisers, refineries, paper, chemicals etc. which have simultaneous demands for process steam as well as electricity, are permitted to generate steam at higher pressure and have a capitive power plant. It has been roughly estimated that on an average about 10 MW of incidental power can be generated by each of the bigger industrial units. Thus, total additional power to the extent of almost 2 million KW can become available by applying the total energy concept with marginal increase in the total fuel consumption. The NCST has identified that the National Productivity Council should continue to propogate this concept.

Anti Corrosion & Tribology Services

Considerable economies by way of higher productivities can be achieved, if the right advisory services on lubricants and anti-corrosion are made available. The NCST has identified that the National Productivity Council could enter these specialised fields. The NPC has worked out proposals for developing these additional consultancy services during the Vth Plan Period.

Institute for Energy Studies/Planning

The Energy Survey Committee of India in 1965 and subsequently, the Fuel Policy Committee in 1972, have recommended the setting up of a full time Institute for carrying out energy studies on a continuing basis. The NCST has drawn up a conceptual framework for such an Institute. The UN Committee on Natural Resources has also recommended that the setting up of National Energy Institutes in member countries should be encouraged.

The rapid growth in energy consumption together with changes and shifts in patterns of inter fuel substitution has focussed the need for forcasting future growth trends, both of energy supply and energy demand, keeping in view the country's meagre resources and vast population. In addition :—

1. Energy consumption, particularly, consumption of fuels such as oil that are imported, have increased and grown at a rate faster than the rate of growth of G. N. P. of the nation.
2. Number of technological advances have opened new frontiers in the exploration & development of a wide variety of energy sources.
3. Accelerated rate of development and a new socio-economic climate have created the need for far reaching changes in the structure, organisation, ownership and management of the energy industry.

4. On account of the considerable time lags between explorations, development production and utilisation of energy resources, an integrated and coordinated planning for future energy requirements is called for.
5. Disparities, both in terms of geographic areas and economic classes, is staggering i immensity, thus making India in parts the most primitive and in parts the mos advanced country.

The above amply justifies the setting up of a full time Institute devoted to carrying ou energy planning, based on continuing long term studies.

Solar Energy Utilisation

An expert group on solar energy has recommended R&D Projects for implementation i the Vth Plan. To start with, a detailed exercise on why solar devices have not found popula application, underway. Some promising areas of application are :

1. Solar dryers, radiation and convective types, for seasoning of wood, grain drying b aeration.
2. Solar space heating systems for high altitude, unit room heaters etc.
3. Solar ice making machines and refrigerators.
4. Solar air-conditioning-unit room coolers, large air conditioning system, etc.
5. Solar desalination and distillation.

It has been noted that SSPL is engaged on R & D activities on solar cells, such as silicon gallium tellurium cells etc. The expert committee has opined that additional R&D activities o such cells would need to be undertaken by SSPL to meet particular demands, such as for spac application, remote lighthouses/beacons, etc.

Work so far on solar energy has been diffused at several laboratories with work of sub-critircal nature. Thus, the setting up of a separate 'Solary Energy Laboratory' is warranted t undertake intensive R&D programmes and provide technical back up, necessary to popularis promising areas of application.

Tidal Powder

The CWPC have included some preliminary investigations in tidal power in the UNDP country programme involving an expenditure of Rs. 37.500 in foreign exchange and counter-par Indian funds of Rs. 12,500. The NCST Committee on Tidal Power has broadly indentifie costal regions in the country where some R & D work on harnessing tidal power could be considered. With this in view, the NCST has supported CWPC's project proposal for inviting a UNDP expert to advise on the identification of a suitable site. The project report by Centra Water & Power Commission has already been submitted to the Planning Commission, who ha asked for the views of the Department of Science & Technology. The NCST has supported thi project. There is need for carrying out further studies and preparing feasibility reports wit regard to potential location in the West coast and East coast. These reports would indicat whether experimental R & D units can be considered for installation in the Vth Plan.

Wind Mills

The wind data from over 400 meteorological stations has been analysed and it has bee assessed that there are several regions in the country where wind mills for water pumping an electric power generation can be utilised. Whilst work on wind mills at NAL has been disconnued, the CPRI, CAZRI and Auroville have taken over work with regard to power genera- on and water pumping. A proposal has been drawn up using the wind mills developed by AL in cluster form for pumping applications. Some specific locations (such as Veraval etc.) ve been identified for trials. Successful demonstration would lead to the popularisation of wind ills. for pumping. Another proposal for indigenously manufacturing 5-10 KW wind electric nerators based on foreign designs available in the country, and putting them to field trials s been drawn up. Wind mills in conjunction with storage batteries appear promising for rural ectrification applications.

Whilst proposals for the installation of fresh wind mills in clusters for water pumping d electric power generation are being considered, it is recommended that the existing wind ills already installed be restored back to service. It has been assessed that almost 50 per cent the wind mills in the country are installed in the State of Mysore, particularly around ngalore area. The setting up of small O & M service units at CPRI and CAZRI would able these wind mills to be restored to services.

eothermal Energy Utilisation

The interest in geothermal energy has been revived in many countries and extensive R&D exploration and utilisation is under way. Whilst exploration efforts by NGRI and CWPC nder UNDP) are being enhanced, it is recommended that some R&D on utilisation in omising areas of application should also simultaneously be initiated in the Vth Plan. Central ating in Ladakh and refrigeration in Manikaran hold considerable promise. It would even worthwhile to put up a small 5-10 MW steam turbine for trials, once the exploration work s progressed. As CWPC is already actively involved in these areas of application, they are st equipped to take up the R&D work.

attery Driven Vehicle

The transportation sector at present consumes 30% of the total petroleum products, with e automotive sector itself consuming about 10%. In order to reduce dependence on oil oducts, which are largely imported presently and will continue to be imported for quite some ne to come, as well as from the pollution considerations, a NCST Export Committee has recom- ended the devlopment of a battery driven vehicle. The committee was of the view that the test technological advances already achieved in foreign countries should be adopted for this oject rather than mere replacement of the engine by a power pack. In addition, if possible, e of gear box, rear differential and other conventional items, wherever feasible, should be elimi- ated whilst designing the vehicle. This project when successful and put to commercial use ould enable utilisation of electric power needed for charging the energy source during off-peak ours. This vehicle project, once developed and productionised, would revolutionise the automo- le industry to a great extent and may considerably relieve pressure on automobiles being anufactured based on present conventional technology. This R&D project would automatically ad to consideration of heavier vehicles (based on fuel cells) for mass communication purposes urban centres.

The total outlay involved for this project is Rs. 18 lakhs, comprising Rs. 4 lakhs to be spent RDOEI (Min. of Heavy Industries) on controls, Rs. 3 lakhs by RDSO (Min. of Railways) motors, Rs. 6.6 lakhs by CECRI (CSIR) on power pack and Rs. 4.4 lakhs by VRDE Defence) on vehicle.

ong Term R & R Chemical Energy Sources

For rural electrification and automotive traction applications, long term R & D projects on hium cells, sodium-sulphur cells, metal air cells, and H_2O_2 cells have been identified for implementation at CECRI, Karaikudi. Though there are other smaller laboratories in the countr working in the field of electro-chemistry, it has been assessed that CECRI is best equipped t take up these long term R & D programmes of national importance.

Steering Committee & Development Board for Chemical Energy Sources

The setting up of a steering committee is recommended to coordinate and monitor the R& projects on development of chemical energy sources identified by the NCST expert group. A several organisations would be involved in these projects, the steering committee could period cally meet to review the progress in relation to stipulated physical, financial and time target The steering committee, in addition to representation from organisations actually involved in th R&D activities, would also have representation from Finance, DGTD, DST, etc. At preser there are several organisations independently pursuing their developmental/manufacturin activities in the field of chemical energy sources. There is, therefore, urgent need for setting u a 'Development Board for Chemical Energy Sources' for reviewing and coordinating all activiti in this field. In addition, there is also need to constantly review battery/fuel cell developmer abroad, review appropriate technologies suitable for indigenous conditions, render advice c foreign collaborations, desseminate information and data on imported technologies to othe prospective users, advise on improvement of existing indigenous technologies and review all or going R & D work as well as facilities in the country. The 'Development Board for Chemic Energy Sources' would not have fulltime members, but will have representation from organisatior such as Defence, CSIR, P & T, manufacturers, Railways, Academic Institutions, Industri Development and DST.

The Member-Secretary/Convenors for the above would be from DST, who would al provide the necessary secretarial assistance. The financial outlays involved would be by w of travelling expenses and TA/DA.

Aero Gas Turbines for Power Generation

Gas turbines are attractive for meeting peak load and emergency power requirements. Du gas-cum-steam turbine cycles enable efficiencies of over 50 per cent to be achieved, there enabling higher utilisation of the coal reserves. The R&D work aims to industrialise aero gas tu bines for land based power generation. The IAF is due to phase out about 200 engines out service, which can be used for power generation, provided R&D is started immediately. R&D gasification of coal as an alternative to petroleum fuel is also envisaged. It is recommended th R&D work on aero-gas turbines must be taken up immediately. In February 1973, Ministry Finance have already released Rs. 75,000 in foreign exchange against which 4 phased out RA aero-engines have already been imported. The results of R&D efforts available at the end of years would enable the installation of at least 2 aero-gas turbine sets, each of 10 MW generati capacity.

The financial outlay for this project would be Rs. 9 crores, comprising Rs. 2.9 crores GTRE on gas turbine, gear box etc., Rs. 5 crores by BHEL on generator, switchgear contro etc. and Rs. 1.1 crores by CSIR on coal gasification.

R & D for Low Temperature Carbonisation (LTC) Plans

In view of the growing dependence on non-commercial fuels, as well as dependence on products such as kerosene, LPG, etc., an NCST expert group recommended that 2 Low Tem rature Carbonisation plants be set up to produce smokeless solid fuel for domestic consumpti The group was of the view that technological skills were available indigenously for setting up LTC plants, one located in the Bengal-Bihar areas, based on the externally heating process de

ped by CFRI suitable for weakly caking and semi-caking coals, and the other in the Godavari
lley, based on the internally heating process developed by RRL Hyderabad suitable for non-
oking coals. The group proposed that detailed project reports be prepared and specific recom-
endations be made to Government. Consequently, NCST has made appropriate recommendations
r the setting up of these 2 LTC plants which would require Rs. 5 crores for the supporting R&D
ork, about Rs. 2.5 crores for the Godavari Valley plant and Rs. 2.5 crores for the Bengal-Bihar
ant at RRL Hyderabad and CFRI respectively.

&D for Coal-to-Oil Plant

In view of the increasing import bill on account of oil, the expert group recommends the set-
ng up of a coal-to-oil plant capable of producing ½ to 1 million tonnes of middle distillates
er annum. The group proposed that technical specifications for issuing a global tender enquiry
e urgently drawn up. Consequently, NCST has made appropriate recommendations in this regard
the Cabinet. It has been estimated that a coal-to-oil plant producing about 1 million tonnes of
l products may cost about Rs. 40—60 crores, depending on the process and bye-products. Such
plant would replace the equivalent of about Rs. 15 crores worth of oil imports per annum. To
evelop the necessary technological competence indigenously, an R & D outlay of about Rs. 5
ores would be necessary for work to be carried out at research laboratories such as RRL
yderabad, CFRI, IIP, IOC, etc.

&D to Improve Availability and Utilisation of Existing Installed Generating Capacity

It is noteworthy that the thermal stations in the country generate, on an average, about 3500
WH of power per KW installed (i.e. plant factor of about 40 per cent) against leading world
gure of Japan 5635, USA 4700 and USSR 4700. The comparatively poor performance of the
enerating capacity (coupled with almost the highest transmission and distribution losses) has
ecessitated the provision of generating capacity with a wide and un-economic margin. For a
eak load demand of 14 million KW at the end of the IV Plan, the generating capacity to be
nstalled will have to be about 20 million KW. This low level of efficiency has been assumed to
ontinue upto the end of V Plan. Thus, NCST has recommended that immediate efforts, should
e made to assess what R&D measures can be undertaken to improve the utilisation of existing
hermal power plants. The RDOEI has prepared a report on the setting up of visiting teams for
rouble shooting and diagnostic type studies relating to operation and maintenance of thermal
lants and associated power systems. Detailed R&D plans to improve the performance of equip-
ent would then be drawn up for implementation at appropriate research laboratories.

oal Slurry Pipeline

The coal resources in the country are generally unevenly distributed at great distances from
e consuming centres. Railways have been the main mode of transportation so far, though under
pecial locational circumstances alternative mode of transportation, such as Water-ways and Rope-
ays are also used. Another potentially attractive mode is conversion of coal into slurry and its
ansportation hydraulically through pipeline. Such a mode of transportation would be ideally
uitable for meeting demand of bulk consumers whose requirements are large as well as constant.
echnological competence for such mode of transportation does not at present exist in the country.
onsiderable R&D on coal slurry transportation has been carried out in several countries of the
orld. Feasibility reports for iron ore slurry transportation had been carried out though no pro-
ects have yet been implemented in the country. The Fuel Policy Committee as well as the NCST
ave identified the necessity of developing this technology indigenously. In the first instance,
would be necessary to prepare a feasibility report specifically formulating a proposal for the set-
ng up of a proto-type slurry pipeline as an R&D venture. This report would enable an investment
ecision to be taken on the setting up of a proto-type slurry pipeline.

SECTOR--MINING, STEEL & METALLURGICAL INDUSTRY

MINING, STEEL AND METALLURGICAL INDUSTRY

A. *Introduction*

The Mining, Steel and Metallurgical Industry is recognised as one of the important sectors feeding the core industries of the economy. Basically, this sector has to provide material inputs to the various types of industries producing engineering goods and machineries. The various important sectors of economy needing the inputs from this sector are Heavy Engineering, Defence, Atomic Enery, Spare and Marine Engineering etc.

Though the importance of this sectors has been well established, the present RDD expenditure in the field of metallurgy is incommensurate with the magnitude of investments in the economy. Keeping in view the ultimate aims of achieving self-reliance, increase in productivity, import substitution etc., the investment in RDD effort, particularly in the extended field of Mining and Metallurgy, requires to be enhanced.

B. *Importance of Research, Design and Development*

It has been observed that the installed capacities of most of our plants set up in collaboration with foreign countries are being under utilised. On the other hand the demand for the materials by the various sectors of economy has been growing rapidly necessitating thereby imports. The reasons for this slow rate of growth have been attributed to the poorer techniques of beneficiation and extraction of the materials; lack of indigenous availability of maintenance materials meeting the specifications laid down by the foreign collaborators and the lack of personnel readily available for tackling the problems encountered during the major break downs.

As a consequence, the shortfalls in indigenous supply of the requirement of materials of the various sectors of the economy are being met through imports.

For example, India's present requirement of nickel is 6000 tonnes costing around Rs. 24 crores would be necessary for work to be carried out at research laboratories such as RRL Rs. 8 crores. Similarly we are importing large quantities of stainless steel. Difficulties encountered in importing these materials triggers off slippages in the various dependent industries.

Thus it is apparent, that for every unit of foreign exchange spent in importing the know-how and materials, there is a corresponding effect resulting in much higher expenditure of the foreign exchange. Conversely, if indigenous efforts through RDD could save one unit of foreign exchange expenditure there would be an appreciable decrease in the pressure on our foreign exchange. To make these RDD activities effective, it is essential that the investment in technology be made prior to the commercial investment so as to readily absorb the technology underlying the imported unit.

C. *NCST Approach for bridging the gaps*

Keeping in view the aims of achieving self-reliance, import substitution etc.. NCST Panel had formed the following 15 Sub-panels that covered activities in the entire sector of Mining, Steel and Metallurgical Industry. This Panel had kept in view the gaps existing in exploration, exploitation and production of materials and had formulated the RDD programmes in order to bridge these gaps.

These programmes have been drawn with the involvement of a wide cross-section of selec engineers, metallurgists, educationists and industrialists. Wherever possible, the organisations for implementing these programmes have also been simultaneously identified in consultation with the agencies concerned wherever possible.

A Core Committee formed at the instance of Shri C. Subramaniam, Minister for Industrial Development and Science and Technology, and late Shri M. Kumaramangalam, Minister for Steel and Mines, critically examined the reports and documents prepared by the various Task Forces and the Working Groups constituted by different ministries and have finally brought out an integrated plan in this sector.

In all 243 RDD projects have been identified under 15 different sub-panels. The sub-panel-wise number of projects and sub-panel-wise break-up of financial outlays are given below.

Sub-panel	No. of Projects	Funds (Rs. in lakhs)
Ores and Minerals	2	599.00
Coal and Coke	6	502.75
Iron and Steel	10@(2)	2,905.00
Special Steels	11	468.40
Common Non-Ferrous metals	20	8,240 60
Special Non-Ferrous Metals	8	387.27
Rare Metals	16	1,364.59
High Purity Metals and Super Alloys	4	75.21
Foundry and Forge	8	38.40
Powder Metallurgy	7	89.95
Refractories	6	119.00
Ferro-Alloys	4@(1)	24.25
Metallic Corrosion and its Prevention	12	183.92
Mining	29@(1)	1,046.70
Metallurgical Research in Educational Institutions	100@@(1)	366.51
Total	243	8,995.55

NOTE —@(i) Represents the transfer of projects to other panels. The quantity in the bracket indicates the number of projects transfered. Though the projects have been indicated in the sectoral report the funds for such projects have not been taken into consideration.

@@(1) indicates project (7,15,90) which have been cancelled.

These programmes will directly result in the utilisation of indigenously available raw materials, increased productivity, import substitution, development of new process technology in strategic areas etc.

A few important projects are : improvements in blast furnace productivity, direct reduction of iron ores using non-coking coals, production of formed coke, recovery of nickel and cobalt from indigenous ores, development of basic refractories for LD convertors with extended lining life, improved mining methods etc.

These programmes also include the following proposals put up separately by the Department of Steel and Department of Mines. The proposal submitted by the Department of Steel is on the setting up of a plant for 'Electrolytic Manganese' based on the dioxide process developed at NML. The estimated cost of this plant is around Rs. 3 crores. This proposal is included in the sub-panel on Special Non-Ferrous Metals. The proposals put up by M/s. Bharat Gold Mines Ltd., under the Department of Mines, with the estimated expenditure are as follows :

1. Development in Gold Mining	34.50 lakhs
2. Seismic Project	12.00 lakhs
3. Micro Seismic Project	12.00 lakhs
4. Material Testing Laboratory	18.00 lakhs

These proposals are included in the sub-panel on Mining.

It has been observed that the facilities available in the country for ore dressing investigations, mine planning and design, mine safety and extraction by different techniques are not adequate to undertake the planned S & T programmes during the next Five Year Plan period. These gaps have been critically examined and augmentation of necessary facilities have been provided for in this plan.

Amongst the other RDD programmes identified in this sector, the programmes on the production of formed coke, magnesium, special metals and super-alloys have also been included with the main objective of highlighting the scope of exploitation of RDD results on a commercial scale. Action has already been initiated for Rs. 4 crore project for the production of formed coke at Talcher. The project is based on the CFRI process and NCDC will implement it. Like-wise, the process for production of magnesium developed by CECRI will be exploited on a commercial scale. Though an indication of the expenditure to the extent of Rs. 3 crores for this plant has been given in this plan, it is expected that a major portion of this amount will be provided by the entrepreneurs. Lastly, the plan for the manufacture of special metals and superalloys proposed by DMRL has already been approved by the Government and this Plant will come under the Ministry of Defence. Accordingly, funds for this plant have not been reflected in this document.

It is intended that basic and fundamental research be encouarged at the universities/IITs so as to build up expertise in particular fields around specialists. The sub-panel on Metallurgical Research in Educational Institutions has suggested an outlay of Rs. 3.67 crores for basic research in this area. Apart from this, some of the other sub-panels have also suggested some programmes to be implemented by Universities/IIT's at an outlay of Rs. 1.33 crores. Therefore, the total financial outlay required for such basic work is Rs. 5 crores. This step will pave the way for guided RDD so that efforts can be meaningful both for the present and future requirements. However, many universities/IIT's have their own programmes of work which are financed from their respective budgets. Such programmes have not been included in this sector.

Once the integrated plan is approved and the funds made available, it is proposed to have a number of monitoring committees consisting of 3 or 4 experts in each area which will allot projects with time-bound commitments to various RDD centres, recommend augmentation of facilities wherever required, review the progress of the projects periodically and apply mid-course corrections including discontinuation of a project where called for.

The work of the monitoring committees will be scrutinised by a reviewing committee consisting of amongst others, the Chairmen of the different monitoring committees. The reviewing committee will provide general guidelines to the monitoring committees and decide the policy in terms of utilisation of the results of the researches, liaison with the industrial centres and examine if turn-key jobs could be provided to the industries. In brief, the reviewing committ will examine the flow of two-way traffic between industry and RDD efforts. In addition, will be necessary to set up suitable agencies for collection of data regarding status of technolo for relevant areas and collect information about the demand, supply and import position various materials. These details will be relayed to the monitoring committees and also to t entire metallurgical community for programming the line of action.

For successful implementation of such a plan it would be necessary to introduce dynam personnel policies and root out red tapism to the minimum so that the time targets can maintained.

The programmes of NCST were reviewed recently and as a result thereof the followi projects from Natural Resources Panel and Heavy Engineering Panel respectively have be accommodated in the projects proposed by the panel on Mining. Steel & Metallurgical Industr The projects thereby included are as given below:—

Project Index No.	Title of the Project
$S_2G_4A_5P_1$	Setting up a Coking Coal Research Institute.
A_8P_2	Setting up of a Central Shaft Sinking Organigation.
A_8P_3	Setting up of three Central Design Institutes for Mineral Industries for ferrous, non-ferrous and coal respectively.
A_2P_5	Investigations on hydraulic transportation characteristics of iron-ore fines.
A_5P_{10}	Pipe-line transportaiion of coal.
A_3P_7	Field tests and pilot plant studies for recovery of lead and zinc by imperial smelting process.
$S_4G_6P_6$	Non-Ferrous Research Centre.

Project Index No.	Title of the Project Panel—7	Project Index No. Panel—2	Financial Outlay (Rs. in lakhs)	
			Panel—2	Panel–
$S_7G_{14}P_1$	Setting up of a Central Mine Planning and Design Institute (CMPDI) with Regional Centres.	$S_2G_4A_5P_1$ $S_2G_4A_8P_2$ $S_2G_4A_8P_3$	100.00 50.00 450.00	450
$S_7G_{14}P_{13}$	Determination of design parameters of hydraulic transportation of solids in pipelines.	$S_2G_4A_2P_5$ $S_2G_4A_5P_{10}$	0.40 4.40	15

This panel had identified various projects for recovery of lead and zinc and in view of t projects $S_2G_4A_3P_7$ of Natural Resources Panel with a proposed outlay of Rs. 10.00 lakhs l also been included in this panel. This project on Non. Ferrous Research Centre (Project In No. $S_4G_6P_6$) has also been included in project No. $S_7G_5P_1$ of this Panel.

HIGHLIGHTS OF IMPORTANT RDD PROGRAMMES IN VARIOUS SUB-PANELS

The sub-panel-wise highlights of the various projects are as follows :

. *Ores and Minerals*

The capacity and facilities available in India for RDD work on ores and minerals have een assessed and considering the requirements, it is recommended that the facilities of IBM, NML, RRL (B) and BARC should be augmented. NML has also a proposal for creating esting and pilot plant facilities. HZL & HCL are also envisaging plants for testing of their res-ective ores. BALCO has a proposal for setting up an Aluminium Institute at Korba where acilities for testing will be provided.

In addition, the work on design and development of mineral dressing equipment has also een identified. Among the ore dressing equipment needed, many are manufactured in the ountry but there are no firms making good quality equipment like magnetic separators, high ension separators, wet concentrating tables, gravity separators etc. India will become self-ufficient not only in all types of ore dressing equipment for research laboratories and industrial lants but also in other related equipment if the required know-how for equipment manufacture developed.

. *Coal and Coke*

The coking coal reserves in India are limited. The RDD programmes identified are there-ore aimed at conservation of coking coal and better utilisation of available coals and hence ey are industry-oriented.

The most important project in this area is that of formed coke. It will have good impact n the economy of the country in general and of coke and iron making in particular as it aims the elimination of coking coal altogether for use in the blast furnace. The country has nough reserves of non-coking coals which can be used for production of formed coke. The roject is based on CFRI process and action has already been initiated for the project. he project would provide low phosphorus formed coke for ferro alloy industries. Additionally, will also have facilities for undertaking tests on other non-coking coals for preparing sizeable uantities of formed coke for trials in blast furnaces etc. If these trials are successful, the esources position for the iron and steel industry would be vastly improved and the industry n draw upon non-coking coal fields.

Some of the other projects identified cover problems on benefication, processing and con-rsion of coal to coke for metallurgical use ; some envisage optimisation and standardisation processes and equipment in the washeries and others deal with development of industrial oducts, the know-how for which is difficult to obtain from outside. All these will go a long ay to help develop indigenous know-how, promote commercialisation of processes developed the country and substitute imports of machinery and equipment.

Iron and Steel

The emphasis in this area has been given to those projects through which the productivity steel could be increased and at the same time coking coal could be conserved either through its substitution or through reduction of coke rate. Emphasis has also been laid upon the development of new processes for improvement in the steel production. The major thrust programmes proposed are :

A. *Direct reduction of iron ore with solid reductants* :—The project is aimed at the production of sponge iron on a pilot plant scale. The test unit would be of 200-300 t.p.d. initially and which would be scaled upto a commercial plant of 1000 t.p.d. subsequently.

B. *Direct reduction by gaseous reductants* :—The direct reduction of iron with gaseous reductants is stated to have certain advantages but India has the paucity of resources of natural gas which is most widely used for direct reduction in other countries. Our country is having a large supply of non-coking coals of high ash medium volatile quality. The aim of the project is to study the techno-economics of gasification of various non-coking coals and their suitability for direct reduction of iron ore.

C. *Improvements in blast furnace productivity* :—A number of programmes will be initiated with the objective of raising atleast one or two Indian blast furnaces to match the best performance standard attained in the world. In order to minimise coke usage, TISCO is investigating the use of oil and coal-oil slurries. Detailed project studies are now being undertaken for coal dust injection tests in one of the furnaces at Bhilai and Rourkela. A new design o blast furnace top charging mechanism is also being considered.

D. *Trials with OBM and SIP processes for steel making* :—The oxygen bottom blowing process and the sub-merged injection process may have to be licensed from Max-Hutte or Pecor (USA). Negotiations are being undertaken by TISCO and SAIL. Adoption of this process to the Indian conditions has to be done at the furnaces at TISCO or at one or the other steel plants.

E. *Development of continuous casting technology* :—This programme would consist of number of inter related projects (a) operation of LD in a creditable way to improve performanc (b) development of special refractories for continuous casting (c) operation and control o the casting machine. Some of the projects on improved operation of the LD converters ca be undertaken in the existing plants and the development of refractories can also be done here

F. *External desulphurisation of hot metal* :—TISCO has already carried out trials on Swi desulphurisation method and other schemes such as rotary desulphurisation, use of Mag-Cok etc., will have to be investigated. Desulphurisation will become necessary when LD an continuous castings are in operation.

G. *Process Computer Control* :—Bokaro steel plant is planning to install a process contro computer for one of the blast furnaces and for LDs. TISCO has a similar proposal. Th Bokaro proposal calls for installation of the computer and operation within 18 months. Th computer is being selected.

H. *Development of instrumentation for the use of steel plants* :—In the steel plants, the is need for a large variety of instruments. They include, items such as load cells for weighin load cells for mill pressure determination, analytical instruments and other transducers f computerisation of processes. Programmes will have to be developed in conjunction with t relevant electronics and instrument manufacturers of such instruments.

4. *Special Steels*

In this area there are two projects identified as of a major thrust.

(1) development of electro-slag refining technology; and
(2) development of basic oxygen process for making high alloy steels by B processes.

The development of ESR technology is a potential metallurgical tool for improving the uality of various grades of steels and other alloys. The process is popular in industrially eveloped countries. In India, besides TISCO which has the know-how of remelting by this rocess, both NML and IISc have been working in this area. In addition, DMRL also is lanning to develop this technique for establishing parameters for refining various grades of lloys proposed to be manufactured in the Special Alloy Plant which has already been approved y the Govt. Since the demand for special steels and other high purity metals and alloys is on e increase, development of this technique for establishing the various parameters for different etals and alloys has been emphasised.

The LD converters are in operation in Rourkela steel plant and Mysore Iron & Steel Ltd., he steel making at Bokaro is also based on the same process. All these plants are producing nly mild steels from LD converters whereas in advanced countries special steels and alloys are eing produced by this process. It is true that the quality of pig iron fed to our LD converters inferior, compared to that in countries abroad, where special and alloy steels are being produced y LD process, but no concentrated effort has yet been made to produce special and alloy teels by this process in our country. Proposal is to develop this process for manufacture of pecial steels as this will have immediate impact on the cost of special and alloy steels.

The demand for alloy and special steels in a developing country like India is bound to o up with time.

We are importing a large quantities of special steels in order to meet our demands. Thus here is a gap between indigenous demand and supply of special steels. In view of this gap, levelopment and commercialisation of steel products has to be undertaken on a continued basis nd the projects have accordingly been identified as of normal priority.

. COMMON NON-FERROUS METALS

The metals considered under this area include aluminium, copper, lead, zinc and magneium. Considering the demand and supply position of these metals and alloys and the plants roposed to be set up to meet the gap, the RDD programmes identified as of major thrust nclude :

(i)* setting up of facilities for hydro-metallurgy and electro-metallurgy ;

(ii) production of magnesium ;

(iii) development of high strength aluminium alloys for air-craft, defence and space industries.

In view of the fact that the non-ferrous metals position is not satisfactory in India, imortance has also been given to development of roasting techniques and treatment of residues or increased metal recovery, utilisation of wastes for conservation of metals, import substitution vith indigenous materials, treatment of low grade ores for augmenting the indigenous supply nd improvement in surface finishing.

. SPECIAL NON-FERROUS METALS

The metals under this area include nickel, tin, chromium, manganese, cobalt etc. Identiication of the projects as of major thrust is based on the principle "replace tin and conserve nickel". Tin is not available in India and all of it is imported. Restricted use of tin alloys lone costs the country directly to the tune of Rs. 10 crores and indirectly about Rs. 8 crores.

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*NCST Panel on Heavy Engineering has suggested a project for carrying out pyro/hydro/ lectro metallurgy and hence it is also being included here in order to avoid the duplication.

Some preliminary work on development of chromium-chromium oxide coating as a substitute for the tin plating has been done as a batch process and it is recommended that immediate steps should be taken to boost it up for developing continued process.

India's present requirement of nickel is being met through imports. This shortage of nickel can be met both by production of nickel from indigenous sources and also by conservation of nickel in the development and production of special series of stainless steel. Since reserves of nickel bearing ores containing more than 0.8 per cent nickel are limited and that with composition below 0.8 per cent nickel are available in large quantities, special emphasis has therefore been given on recovery of nickel from lateritic ores of Sukinda.

The projects which have`been allotted normal priority, mainly include recovery of precious metals, development of high purity metals, development of electrolytic chromium and manganese, recovery of metals from secondary wastes, development and finishing of special metals and alloys. These projects mainly aim at reducing foreign exchange, import substitution and self-reliance in strategic areas.

7. *RARE METALS*

The rare and less common metals find their applications in the field of nuclear power generation, aeronautics, aero-space engineering and electronics. The raw material reserves pertaining to a number of metals, belonging to this category, are quite satisfactory. DAE has been largely responsible for the development of a number of these metals resulting in the establishment of several units for further development and production work. Thus, the base has been established in the country, but to meet the entire requirements of rare metals in all its forms much organised RDD work has yet to be carried out.

The RDD programmes proposed fall in the following broad classifications (a) metals for which raw material resources are abundant and a base already exists for further development of technology (b) metals for which raw materials position is limited and a process technology has already been developed on a pilot plant scale and internal demands are significant (c) metals which occur in very low concentrations in association with ores of other common metals and which get significantly concentrated in the by-product streams, (d) metals for which neither the technology is established nor the resources are available and the country has to depend on imports at least for some time to come.

Accordingly, the projects identified as of major thrust include :

(i) production of copper-beryllium alloys from beryl.

(ii) setting up of a refractory metals development centre.

(iii) research and development activities in rare metals, fabrication.

(iv) development of titanium technology.

The other projects in this group fall under normal priority. The proposals recommended will contribute to the effective utilisation of raw materials reserves, production of strategic materials for domestic consumption, induction of advanced technology and creation of export potentials.

8. *HIGH PURITY METALS AND SUPER ALLOYS*

The high purity metals and super alloys are required for aeronautics, electronics, instrument, space and missible industries. The raw materials for special metals and super alloys are at present being imported. These super alloys are characterised by properties such as high strengths at elevated temperatures, corrosion and oxidation resistance etc. The techniques or their manufacture are sophisticated and distinct from conventional processes. Primarily, hese metals and alloys include nickel and cobalt base super alloys, maraging and high strength ron base alloys, titanium base alloys, controlled expansion alloys, magnetic materials etc.

Considering the requirements and importance of these special metals and the expertise vailable for development of these alloys, the RDD programmes of major thrust have been dentified. They include :

(i) the setting up of special metals and superalloys plant ;
(ii) development of controlled expansion alloys.

The plan for the manufacture of special metals and super alloys has been proposed by)MRL and approved by the Government in principle. In the intervening period of commissioning this plant, the RDD programmes have to be carried out by pooling the facilities of 3ARC, NFC & DMRL.

The projects of Normal Priority include development of gold-platinum alloys and development of materials for high temperature applications etc. Gold-platinum alloys find wide applications in synthetic fibre industry and as thermal fuse wires, dental alloys brazing alloys and older pastes and the requirements are met through imports. This project aims at import ubstitution.

Chromium and niobium based alloys to be developed are the most viable materials for operation at high temperatures. These materials can replace now nickel based alloys for use n the jet engines where high temperature is attained due to operation of engine.

). *Foundry and Forge*

RDD, in the fields of foundry and forge technology, is a continuous process. There is ample scope for new innovations, better and improved materials and processes and more and more efficient designs. The fields are quite broad and are directly industry-based and hence problems keep cropping up, which calls for constant attention and RDD activity.

The projects in Foundry and Forge envisage use of oil as a supplementary to coke in place of its non-availability, utilisation of indigenous raw materials, development of new pattern and mould materials, development of new moulding technique for special alloys and investigations into different forging parameters. The success of these projects will ultimately result in low plant investment cost, increased output, reduced operation cost, better quality of castings and forgings, import substitution etc.

With the advent of new product and component designs as required by defence, aircraft, agriculture, transport, electrical and other industries, the requirements of both the commercial and precision forgings are also progressively increasing. The RDD programmes have been identified to cater for these requirements.

10. *Powder Metallurgy*

The existing powder metallurgy industry in the country is not very well developed. The development of this industry is, to a large extent, related to the development of other engineering industries, such as automobiles, textile, machinery, armament components, automatic machinery etc.

Powder production techniques for common lower melting metals and alloys are fairly established in the country either as a result of work done in our national laboratories and technological institutes or through foreign collaboration to the industries.

In assessing project areas the basic undertone has been industrial research and development work which would create opportunity for further employment and close the technologic gap, minimise drainage of foreign exchange and cause self sufficiency in various metal powde and products.

The projects identified as of major thrust include :

(1) Development and production of special metal powders and their products.

(2) Utilisation of sintered carbide wastes.

The projects which have been allotted normal priority include :

(1) Development of production technology for manufacture of iron and magnesiu powders.

(2) Development and production of bonding material.

(3) Treatment of wear parts and services.

In addition, a Powder Metallurgy Service Centre has been recommended which will provid necessary assistance to the entrepreneur by way of providing test facilities both on the ra materials and end products. This centre will also provide such assistance as may be necessary i setting up a plant.

11. *Refractories*

The present demand and supply position of refractories as well as a forecast for the futu upto 1985, have been assessed. There appears to be a gap between the demand and avai ability of refractories from indigenous sources and in some areas quality needs improvement.

The imports are necessitated by (a) insufficient capacity or output of some particular typ of conventional refractories for which know-how is available, (b) inferior quality of some of th indigenous refractories due to which their performance does not come upto the desired level, (c non-availability of some special types of refractories for which either the know-how is not avai able or the quantity involved is so small that it cannot be manufactured economically indige ously. The first can be remedied by increasing the capacity as the know-how is available. Th second and third call for RDD efforts to develop indigenous know-how and to improve th quality of available products.

The projects identified as of major thrust include :

(i) development of basic refractories for LD converters with improved lining life; ar

(ii) production of electrothermal products such as fused alumina, fused magnesia a fused spinel.

LD vessels are utilised in Rourkela for production of steel and larger vessels are expect to come up in Bokaro. Rourkela has employed a tar dolomite lining for which the specificatic as well as the technology was provided by the collaborators. It is reported that such a lining la only 200 heats whereas the lining like of such LD converters in operation abroad is around 12 heats. In view of the unpredictable lining life, production of steel is suffering. Hence, develc ment work on basic refractories for LD converters has been emphasised.

The electrothermal industries in India have so far been depending upon foreign technolc for establishing and operating their units for production of calcium carbide, fused alumina e th special reference to the utilisation of raw materials available in the country. The indigen-s know-how is not yet developed on a scale which will satisfy the requirements of these indust-s. This proposal has in view, the scaling up of arc furnace technology and exploring the utili-ion of indigenous raw materials for production of electrothermal products.

The other recommendations include RDD programmes as related to the steel industries, cluding continuous casting process, glass works and power generation by reactors. In addi-n, they include development of fusion cast refractories, carbon blocks for blast furnace, lining aterials, heating elements and refractories for applications in vacuum melting techniques and her fields.

In the Core Committee, it was brought out that the steel industry, in active collaboration th its active refractory units, is already seized with the problem of refractory development and nsiderable investment has already been planned for research work in this field. The problem refractories development, according to the steel makers, is best solved by direct collaboration tween refractories manufacturers and the users. To this end, the SAIL and other steel plants e directing their efforts. Considering the total value of refractories used in the country, almost to 85 per cent is used by the steel industry and most of the development work would, erefore, be undertaken through the steel plants and the refractory manufacturers.

However, the question of refractories required for non-ferrous metals such as copper, alumi-um, zinc has yet to be covered and it is expected that this will be looked into by the respective ganisations such as Bharat Aluminium Co., Hindustan Copper, Hindustan Zinc etc., who e likely to plan their refractory requirements. This leaves out other special refractories which ay be of sophisticated nature, like alumina-silica, graphite etc., which are required in small antities but in a variety of products. It is felt that these products could form the basic work CECRI and NML.

. *Ferro Alloys*

The RDD efforts in this area are viewed from two different aspects *viz.,* (i) the efforts eded in the field of tonnage ferro alloys like the ferro manganese, ferro-silicon, ferro-chrome d ferro-vanadium, where RDD efforts are required mainly in raw material preparation, ways d means of saving electrical power consumption and utilisation of wastes (ii) the efforts needed the field of special ferro-alloys and other alloys which are required in small tonnages of the der of a few kilogrammes to a few hundred tonnes. The RDD efforts in this case are required ainly in the development of the process know-how itself in order to get higher yields and con-stent quality. The major RDD programmes in these two fields have been identified.

Work on evaluation of burden materials and study of slag characteristics in the production ferro alloys has been given normal priority.

. *Metallic Corrosion and its Prevention*

The RDD programmes on metallic corrosion are based on two considerations *i.e.* (i) con-ol and (ii) prevention. The annual investment on corrosion prevention is of the order of s. 1,500 millions in 1961 and this investment will increase to Rs. 3,500 millions by the end of e Fifth Five Year Plan. If unattended to, losses due to corrosion will be several times the invest-ent on corrosion prevention. The RDD programmes therefore include development of anti-cor-sion products and processes suited to the climatic and environmental conditions in this country d application of corrosion preventive measures in the industry and services.

The projects of major thrust include:

(i) establishment of Corrosion Advisory Board with Regional Centres; and

(ii) augmenting of Tropical Corrosion Testing Station at Mandapam Camp.

The main function of the Corrosion Advisory Board will be disseminate detailed information to the industry and render services on corrosion preventive measures. It will also offer consultancy and engineering service for implementation of corrosion preventive measures and carry out techno-economic analysis of the different corrosion preventive measures.

The main objective of the Tropical Corrosion Testing Station at Mandapam is to assess the tropical performance of various types of protective schemes. Corrosion in tropical and especially tropical marine location is more-severe and results in rapid failures of protective coatings. Millions of rupees are being spent towards such protective coatings. This project will ultimately result in the development of more satisfactory and economical protective coatings.

The projects which have been allotted normal priority will be of continuous nature because it is needed to introduce anti-corrosion procedures suited to the conditions of time in this country.

14. *Mining*

It is observed that RDD effort in the mining industry in India has been minimal and good design knowledge is sadly missing, except in some limited places/areas. This is highly unfortunate, as mining is a particularly hazardous industry with a labour-intensive pattern. Lack of adequate design capacity in coal mining industry has been recognised as a technological gap. With a view to bridging the gap in design of coal mines, Central Mine Planning and Design Institute has been recognised as a major RDD programme.

Four other areas of major thrust in mining have been identified. They relate to:

(i) the development of new coal mining methods;

(ii) assessment of ground movement and damage due to underground mining operations;

(iii) finding substitutes for the method of hydraulic sand stowing in mines; and

(iv) developing methods for dealing with mine fires.

The objectives are higher percentage of extraction, mines safety, prevention of damage to the surroundings and utilisation of available raw materials for stowing.

Currently RDD effort in mining is confined mainly to the Central Mining Research Station, Dhanbad. The group feels that facilities for such work at a few additional centres should also be augmented *viz.* at the Directorate General of Mines Safety in the area of mine safety and at the three Central Mining Educational Institutions (which are the only ones running post-graduate and Ph. D. programmes in mining) in areas within their respective fields of competence. There is also need to improve the resources position of CMRS to enable it to suitably increase its activities during the Fifth Plan.

Development of mining machinery suited to Indian conditions in respect of geology of deposits, though does not fall strictly within the ambit of the term mining research, but is of crucial importance to the mining industry.

15. *Metallurgical Research in Educational Institutions*

It is intended that basic and fundamental research be encouraged at the universities/IITs so as to build up expertise in particular fields around specialists. This step will pave the way for guided RDD so that efforts can be meaningful, both for the present and future requirements. However, many universities/IITs have their own programmes of work which are financed from their respective budgets. Such programmes have not been included in this sector.

The projects identified by the various Sub-panels are as under:—

Project Index No.	Title of the Project	Financial Outlay (Rs. lakhs)
1	2	3
	G_1 Ores and Minerals	
$S_7G_1P_1$	Augmentation of facilities for ore dressing and agglomeration	585.00
2	Design and development of mineral dressing equipment	14.00
		Total G_1 599.00
	G_2 Coal and Coke	
$S_7G_2P_1$	Production of formed coke from non-coking coals	400.00
2	Production of formed coke by briquetting	7.00
3(a)	Renovation of pilot coke oven battery for testing of coal blends	70.00
(b)	Selective preparation of coal for coking	2.00
(c)	Selective extraction and selective agglomeration of coal to produce low ash product .	18.00
4	Development of integrated process (oleoflotation) for upgrading and dewatering of small coal.	0.80
5	Standardisation of washing circuit and washery equipment for treatment of coking coals	0.75
6	Development of high performance least erosion graphite product	4.20
		Total G_2 502.75
	G_3 Iron & Steel	
$S_7G_3P_1$	Direct reduction of iron ores with solid reductants and the use of the product (sponge iron) in the Electric Steel Making Furnaces.	350.00
2	Computor control for processes in steel industry	150.00
3	Improvements in Blast Furnace productivity and reduction of coke rate . . .	1000.00
4	Trials with OBM and SIP processes for steel making	100.00
5	Development of continuous casting technology with particular reference to LD operations, quality and productivity.	1,000.00
6	External desulphurisation of hot metal	50.00
7	Direct reduction by gaseous reductant with the gassification of locally available high volatile non-coking coal.	55.00
8	Development of instrumentation for steel plant	200.00
9(*)	Studies on utilisation of steel plant wastes	..
10(**)	Studies on environmental control in iron and steel industry (to minimise affect on ecology)	..
	Total G3	2905.00

(*) Project transferred to Recycling of Wastes panel and hence funds not included here.

(**) Project transferred to Environmental Quality & Pollution Control panel hence funds not included here.

1	2	3
	G_4 Special Steels	
$S_7G_4P_1$	Development of the electro-slag refining technology for various grades of alloys	100.00
2	Development of basic oxygen proceess for making high alloy steels by BOF process	200.00
3	Development of suitable stainless steels for Phosphoric Acid service	14.50
4	Development of improved Austenitic Stainless Steels for nuclear cladding	5.00
5	Development of suitable alloy for high temperature reformer tubes	28.00
6	Development of creep resistant steels	62.00
7	Development of Austenitic Grades of Stainless Steels with partial substitution of nickel by Mn, Cu & N_2.	21.00
8	Development of cold heading/rivetting quality steels	13.00
9	Determination of Parameters for production of the free cutting steels and establishment of facilities for measuring machinability.	13.00
10	Hardenable stainless steels for razor blades and surgical instruments	5.00
11	Development of Ferritic Stainless Steels, Specialy Fe-Cr-Al alloys, with improved toughness, formability and high temperature resistance.	6.90
	Total G_4	468.40
	G_5 Common Non-Ferrous metals	
$S_7G_5P_1$*	Setting up of facilities for hydro-metallurgy and electro-metallurgy with special reference to Ni, Cu, Zn, and Cr.	255.00
2	Setting up of a production unit for magnesium metal by electrolytic process (1500 tonnes/year).	300.00
3	Development of high strength Al-alloys for aircraft, defence and space industries	100.00
4	Pilot plant production of cryolite from Fluorine compounds	35.50
5(a)	Improvement in copper refining process by use of high current density	10.50
(b)	Improvement in copper refining process by use of periodic reverse current	8.78
6	Recovery of non-ferrous metals from secondary wastes	16.10
7	Treatment of leach residues from zinc plants	7.50
8	Recovery of zinc from moore cake	3.75
9	Development of high purity zinc for die-casting	5.50
10	Studies on spray roasting of lead concentrates	6.30
11	Recovery of zinc and lead from lead blast	0.90
12	Continuous wire and strip anodising of aluminium	16.70
13	Continuous copper or nickel plating on aluminium wire	4.95
14	Copper plated aluminium bus bars	5.61
15	Improvement in electrical conductivity of aluminium and its alloys	15.00
16	Production of super purity aluminium	9.50
17	Extraction of copper by a pyro-cum-hydro-metallurgical process developed in DMRL	8.00
18	Development of chlorine metallurgy techniques for the treatment of low grade ores and residues.	14.00
19	Development of dispersion strengthened lead	1.00
20	Reduction of power consumption in aluminium production	Budget to be assessed
	Total G_5	824.59

(*) Project includes $S_4G_6P_6$

1	2	3
	G_6 Special Non-Ferrous Metals	
$S_7G_6P_1$	Pilot studies on recovery of nickel and cobalt from lateritic ores of Sukinda . . .	14.10
2	Development of chromium, chromium-oxide coating as substitute for the tin plating in the Canning Industry.	10.69
3	Recovery of Cu, Ni, Ag & Au, from low grade refractory ores by segregation process .	4.85
4	Electroforming of nickel and copper foils and screens	11.13
5	Preparation of high purity chromium	7.50
6	Indigenous production of cupro-nickel seamless tubes and pipes	15.00
7	Development of : (i aluminium, niobium, tantalum & titanium etched foil type solid electrolytic capacitors, (ii) aluminium, niobium, tantalum & titanium sintered pellet type solid electrolytic capacitors.	24.00
8	Development of production technology for electrolytic Manganese	300.00
	Total G_6	387.27
	G_7 Rare Metals	
$S_7G_7P_1$	Production of copper-beryllium alloys	107.00
2	Setting up of a refractory metals development plant	124.00
3	Research and development activities in rare metal fabrication	80.00
4	Pilot production of titania rich slag and pig iron from 'Q' grade ilmenite . . .	634.00
5	Pilot production of titanium sponge and titanium tetrachloride	355.00
6	Aluminium-Zirconium alloy plant to produce alloys of various composition to meet the requirements in defence and other industries	26.70
7	Perparation of boron trichloride	2.90
8	Development of high-strength copper-titanium alloys	0.57
9	Development of memory alloy	1.09
10	Development of gallium bearing aluminium alloy	1.70
11	Development of special zone-refining techniques for producing ultra-high purity metals	2.40
12	Perparation of boron by fused salt electrolysis	6.93
13	Development of titanium diboride by fused salt electrolysis	7.50
14	Thin film solar cell development	1.75
15	Development of boron and vanadium carbides	6.15
16	Development of rare earth-cobalt permanent magnets.	6.90
	Total G_7	1364.56
	G_8 High Purity Metals & Super Alloys	
$S_7G_8P_1$(*)	Setting up of Special Metals and Super Alloys Plant.	—
2	Development of controlled expansion alloys.	35.65
3	Development of gold, platinum alloys.	7.00
4	Development of Chromium based and Niobium based alloys for high termperature applications.	32.56
	Total G_8	75.21

(*) Project already approved hence no funds indicated here:

1	2	3
	G_9 Foundery and Forge	
$S_7G_9P_1$	Design and development of supplementary oil fired cupola	15.00
2	Development of fluid sand mixtures for moulds and cores	5.60
3	Development of industrial plastics and rubbers as pattern materials	3.00
4	Development of ceramic moulding process	4.30
5	Permanent mould casting of ferrous alloys	3.00
6	Studies of effect of grain flow on impact and fatigue properties in high grade precision forgings.	1.50
7	Investigations on the use of preformed cast blanks for forging steel balls	2.00
8	Classification of forging materials in terms of foregeability	4.00
	Total G_9	38.40
	G_{10} Powder Metallurgy	
$S_7G_{10}P_1$	Production technology for the manufacture of electrical contact materials for switch gear industries.	15.40
2	Production technology for manufacturing tungsten and molybdenum powders and processing them into wrought products.	12.00
3	Utilisation of the sintered carbide wastes and rejects	28.70
4	Production technology and methods for the manufacture of magnesium powder	6.10
5	Production technology for the manufacture of iron powder for welding electrodes and special engineering components	14.55
6	Setting up a Powder Metallurgy Service Centre	8.00
7	Industrial methods for production of powder filler metals for repair of wear parts	5.20
	Total G_{10}	89.95
	G_{11} Refractories	
$S_7G_{11}P_1$	Development of basic refractories for LD Converters with improved lining life	50.00
2	Development of better quality pouring refractories	15.00
3	Production of electro-thermal products such as fused alumina, fused magnesia, fused spienel containing magnesia and titanium carbide.	45.00
4	Development of spraying, patching, plugging materials for coke ovens and stoves	2.00
5	Development of fused rock products.	2.00
6	Development of carbon refractories for blast furnace	5.00
	Total G_{11}	119.00
	G_{12} Ferro-Alloys	
$S_7G_{12}P_1$	Beneficiation, agglomertion and pre-reduction of ferro-alloy ores and fines	15.00
2	Development of technology for producing calceium silicide	4.80
3(*)	Utilisation of ferro-alloy furnace gas and fines	—
4	Evaluation of burden materials and study of slag characteristics in the production of ferro-alloys	4.45
	Total G_{12}	24.25

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*Project transferred to Recycling of Wastes panel, hence no funds included here.

1	2	3
	G$_{13}$ Metallic Corrosion & Its Prevention	
S$_7$G$_{13}$P$_1$	Establishment of Corrosion Advisory Board with Regional Centres	50.00
3	Augmenting of Tropical Corrosion Testing Station at Mandanam camp . . .	23.40
3	Development of anodes for cathodic protection	8.14
4	Prevention of corrosion of underground pipelines by different techniques . . .	23.00
5	Corrosion prevention of underground mining equipment and accessories . . .	15.50
6	Studies on fretting corrosion and wear	3.51
7	Development of high temperature resistant paints	5.25
8	Development of new methods of preparing organic coatings over metals . . .	15.00
9	Pilot Plant production of anti corrosion products and anti corrosion primers . .	9.22
10	Correlation of corrosion protection with physical chemical properties of varnishes and resin films	2.60
11	Studies on corrosion problems in RCC structure	13.50
12	Electro-chemical machining and marking of metals	14.80
	Total G$_{13}$	183.92
	G$_{14}$ Mining	
S$_7$G$_{14}$P 1	Setting up of a Central Mine Planning and Design Institute (CMPDI) with Regional Centres	450.00
2	Development of new mining methods . . , ...	150.00
3	Assessment and control of ground, rock mechanics and structural damage due to underground mining and pit slope stability	50.00
4	Investigations into problems of mine fires and efficacy of different methods of dealing with them	26.20
5	Investigations into suitability of waste materials for stowing in mines and application in pnuematic and mechanical stowers	22.40
6(i)	Augmentation of R&D capabilities at DGMS in the field of mine safety .	50.00
6(ii)	Augmentation of R&D capabilities at ISM for work in the field of system analysis, strata control, equivalent material model studies, blasting and drilling technique, noise and other environmental problems etc.	30.00
6(iii)	Augmentation of R&D capabilities at BHU for work in the field of O/R, stress in worked-out mining areas, equivalent material model studies, blasting mechanics, mine ventilation etc.	20.00
6(iv)	Augmentation of R&D capabilities at IIT (Kh) for work in the field of systems analysis, mine ventilation, studies into characteristics of mine dust, instrument development etc.	10.00
7	Investigations into strata control in underground copper mines	3.75
8	Investigations into problems of rock burst in deep mines	2.70
9	Investigations into application of rock bolting under different mining conditions . .	9.45
10	Design of Bord and Pillar workings for stability and studies on splitting as final operation in one lift	4.70
11	Investigations for improving percentage extraction in thick seams in conjunction with stowing	3.30
12	Economic evaluation of alternative mining methods to determine choice criteria . .	1.70
13	Determination of design parameters of hydraulic transportation off solids in pipelines .	15.00
14	Techno-economic studies of various surface and underground transport systems in mines .	10.00
15	Development of manriding haulage system underground and connected safety device .	5.60
16	Assessment of ventilation and other environmental conditions in mines and development of standards	15.70
17	Methane emission and drainage from highly gassy coal seams	13.80

1	2	3
18	Development of instruments for measuring and recording mine gases	10.00
19	Development of mine rescue apparatus	6.1
20(*)	Research on surface pollution and environmental control in mining areas	—
21	Improvement in exploration drilling technique	20.00
22	Development of instrumentation for ventilation control	10.00
23	Operational research (i) Blasting pattern, tunneling and stowing (ii) On grade control transport and haulage systems.	10.00
24	Development of television aid for applications in mines	10.00
25	Establishing mining exploration circus for small deposit mines	10.00
26	Development in Gold Mining	34.50
27	Seismic Project	12.00
28	Micro-seismic Project	12.00
29	Material Testing Laboratory	18.00
	Total G_{14}	1046.70

G_{15} Metallurgical Research in Educational Institutions

1	2	3
$S_7G_{15}P_1$	Fundamental studies on phase transformations and strengthening machanisms	6.03
2	Production technology for manufacturing tungsten and molybdenum powder and processing to wires and filaments.	Rs. 4 lakhs for this project already catered under Project $S_7G_{10}P_2$.
	Development of resins and other additions and methodology for shell/hot box/cold box process for optimization of composition and other detailed investigations.	2.60
4	Studies on fundamentals of corrosion process	8.60
5	Recovery of non-ferrous metals from secondary wastes	Rs. 3 lakhs for this project already catered under Project $S_7G_5P_6$.
	Augmentation of R & D capabilities in mining for work in the field of system analysis, mine ventilation, studies into characterstics of mine dust, instrument development etc.	Already reflected under Project $S_7G_{14}P_6$(iv)
7	Modelling, simulation control and optimization of static and dynamic mineral, coal, metallurgical and ceramic systems.	7.20
8	Thermo-dynamic studies of metallurgical processes	8.70
9	Development of thermo-mechanical treatment for the strengthening of ferrous and non-ferrous alloys.	18.33
10	Development of improved austenitic stainless steel for nuclear cladding	
11	Surface chemical research related to mineral engineering systems	3.00
12	Growth perfection and characterisation of crystals	7.30
13	Development of multipurpose probes based on solid electrolytes for industrial use.	5.00
14	Viscosity studies on slag systems	3.00
15	Direct extraction of metals from ores/concentrates	2.50
16	Development of multi-purpose probes based on solid electrolytes for industrial use.	Funds provided under Project $S_7G_{15}P_{13}$.

(*) Project transferred to Environmental Quality and Pollution Control panel and hence funds not included here.

1	2	3
17	Production technology for the manufacture of electrical contact materials for switchgear industries.	Rs. 5 lakhs already catered for under Project $S_7G_{10}P_1$.
18	Production technology for the manufacture of bonding materials for diamond impregnated tools.	2.00
19	Fracture behaviour of weldable grade carbon and low alloy structural steels.	11.35
20	Mechinability-evaluation of standard procedures	5.00
21	Viscosity studies on slag systems	Funds provided under Project $S_7G_{15}P_{14}$.
22	Studies on compacting and concentrating of metal powder . . .	4.80
23	Development of ferritic stainless steels specially Fe-Cr-Al alloys with improved toughness, formability and high temperature resistance.	Rs. 5.40 already catered under Project $S_7G_4P_{11}$.
24	Weldability studies	11.10
25	Fundamental studies on phase transformation and strengthening machanisms in steels.	7.50
26	Development of biomedical materials	3.75
27	Controlled solidification of 14% Si-Fe castings	2.50
28	Studies on rapidly-solidified alloy systems	6.90
29	Development of thermoelectric materials	3.70
30	Evaluation of the industrial potentialities of super-plastic forming . .	6.75
31	Development of multi-purpose probes based on solid electrolytes for industrial use.	Funds provided under Project $S_7G_{15}P_{13}$.
32	Studies on bainites in steels	3.40
33	Design and development of a supplementary oil fired cupola . . .	Rs. 2 lakhs already caterred for under Project $S_7G_9P_1$.
34	Studies on crystal defects and phase transformation phenomena . .	6.10
35	Augmentation of R D D capabilities in Mining for work in the field of O/R, stress in worked out mining areas, equivalent material model studies, blasting mechanics, mine ventilation etc.	Funds provided under project $S_7G_{14}P_6$(iii).
36	Development of ceramic moulding process	Rs. 2 lakhs already provided under Project $S_7G_9P_4$.
37	Improvement in the mechanical properties of high alloy casting using micro-chills.	1.70
38	Permanent mould casting of ferrous alloys	Rs. 1 lakhs already provided under Project $S_7G_9P_5$.
39	Study of the effects of Bi and Ti on white iron formation & mechanical properties of black-heart malleable iron from indigenous materials.	1.60
40	Production of wire directly from the melt	4.40
41	Production of aluminium base composite materials by solidification techniques.	2.10
42	Development of indigenous equipment for vacuum induction melting, vacuum arc melting and vacuum casting.	16.00
43	Development of technology for producing calcium silicide . . .	Rs. 4.8 lakhs provided under Project $S_7G_{12}P_2$
44	Development of ferritic stainless steel, specially Fe-Cr-Al alloys with improvided toughness, formability & high temperature resistance.	Rs. 1.5 lakhs provided under Project $S_7G_4P_{11}$
45	Utilisation of by-products of steel industry such as iron oxide fumes, mill scale and fly ash as additions to plastics.	0.50

1	2	3
46	Development of multi-purpose probes based on solid electrolytes for industrial use.	Funds provided under Project S_7G_{15},P_{13}.
47	Thermo dynamic studies of metallurgical processes	Funds provided under Project $S_7G_{15}P_8$.
48	Recovery of non-ferrous metals from secondary wastes	Rs. 1 lakh provided under Project $S_7G_5P_6$.
49	Development of computer programmes to describe temperature-time distributions in solidifying castings.	1.25
50	Continuous wire and strip anodising of aluminium	Rs. 4 lakhs provided under Project S_7,G_5,P_{12}
51	Development of high temperature rapid annealing cycle for production of malleable irons and assessment of properties.	5.00
52	Machinability tests evaluation of standard procedures	Funds provided under Project $S_7G_{14}P_{20}$.
53	Development of ceramic moulding process	Rs. 0.5 lakhs provided under Project $S_7G_9P_4$.
54	Development of high strength heavy duty alloy cast irons without nickel	5.75
55	Development of new compositions for low alloy high strength steels	5.90
56	Development of pressure resistant and high temperature cast iron alloys	7.60
57	Machinability tests & evaluation of standard procedures	Funds provided under Project $S_7G_{15}P_{20}$.
58	Investigation on the use of preformed cast blanks for forging steel balls	Rs. 1.0 lakhs already provided under Project $S_7G_9P_7$.
59	Studies on effect of grain flow on impact and fatigue properties in high grade precision forgings	Rs. 1.0 lakh already provided under Project $S_7G_9P_6$.
60	Development of industrial plastics and rubbers as pattern materials	Rs. 2.0 lakhs already provided under Project $S_7G_9P_3$.
61	Development of bimetallic castings	0.80
62	Classification of forging materials in terms of forgeability	Rs. 2.0 lakhs already provided under Project $S_7G_9P_8$.
63	Development of ceramic moulding processes	Rs. 1.0 lakh already provided under Project $S_7G_9P_4$.
64	Permanent mould castings of ferrous alloys	Rs. 1.0 lakh already provided under Project $S_7G_9P_5$.
65	Development of fluid sand mixtures for moulds and cores	Rs. 3.60 lakhs already provided under Project $S_7G_9P_2$.
66	Design and development of supplementary oil fired cupola	Rs. 2.0 lakhs already provided under Project $S_7G_9P_1$.
67	Investigation on magnetite formation in copper smelting	1.00
68	Grain refinement of aluminium alloys and development of suitable master alloys for grain refinement	2.10
69	Development of chlorine metallurgy techniques for the treatment of low grade ores and residues	11.60
70	Beneficiation, agglomeration and pre-reduction of ferro-alloy ores and fines.	Rs. 5.0 lakhs already provided under Project $S_7G_{12}P_1$.

1	2	3
71	Utilisation of ferro-alloy furnace gas and fines	Rs. 2.85 lakhs already provided under Project $S_7G_{12}P_3$.
72	Evaluation of burden materials and study of slag characteristics in the production of ferro-alloys.	Rs. 4.45 lakhs already provided under Project $S_7G_{12}P_4$.
73	Development of control systems for ferro-alloy furnaces . . .	5.10
74	Press formability of sheet metals	2.35
75	Development of certain metal forming processes with conventional metal cutting machine tools.	1.50
76	Sub-critical forming of plain carbon and alloy steels	1.45
77	Influence of thermo-mechanical treatment on carbide spheroidization in plain carbon and alloy steels.	2.50
78	Classification of forging materials in terms of forgeability . . .	Rs. 2.0 lakhs already provided under Project $S_7G_9P_8$.
79	Development of multi-purpose probes based on solid electrolytes for industrial use.	Funds already provided under Projcet $S_7G_{15}P_{13}$
80	Layering of tool wear surfaces by titanium carbide through vapour phase deposition and study of improvement in tool performance under industrial conditions.	2.40
81	Machinability tests evaluation of standard procedures	Funds already provided under Project $S_7G_{15}P_{20}$.
82	Studies on gases in metal systems	3.10
83	Agglomeration characteristics of fluorspar concentrates and other ores .	2.00
84	Studies on physico-chemical properties of slags	1.70
85	Development of high strength forging steels with indigenous raw materials	3.00
86	Production technology for the manufacture of electrically contact materials for switch gear industries.	Rs. 5.0 lakhs provided under project $S_7G_{10}P_1$
87	Production technology for the manufacture of bonding materials for diamond impregnated tools.	Funds already provided under Project $S_7G_{15}P_{18}$
88	Utilisation of magnetite, concentrates from the Kudermukh magnetite deposits of South Kanara.	2.90
89	Recovery of alumina from South Kanara lataritic clays	2.10
90	Setting up of a Corrosion Testing Laboratory at Suratkal beach under the Metallurgy Department.	—
91	Fundamental floation studies on the minerals of manganese and chromium	2.00
92	Influence of foundary practices on quality of castings	2.00
93	Augmentation of R & D capabilities in mining for work in the field of systems analysis, strate control, equivalent material model studies, blasting design, noise and other environmental problems etc.	Already reflected under Project $S_7G_{14}P_6$(II)
94	For initiating R & D programmes based on their specialisations at BIT, Sindri	3.00
95	-do- at REC, Rourkella	3.00
96	-do- at Engg. college, Raipur	3.00
97	-do- at PSG college, Coimbatore	3.00
98	-do- at Engg. college, Guindy	3.00
99	-do- at Engg. college, Chandigarh	3.00
100	Building up of facilities and equipment for raising the basic standards of teaching and education in Regional and State Institutions.	100.00
	Total G_{15}	366.51

SECTOR:- SPECIAL MATERIALS

SPECIAL MATERIALS

In present day scientific and technological activity, as well as in modern industry, special materials have gained a peculiar significance. In comparison with conventional materials, ferrous and non-ferrous, the quantitative demand may appear small. However, special materials covered by the panel gain importance by virtue of the fact that much of the instrumentation for laboratory work and process and quality control in the industry would not have been possible without these materials. Further, there have emerged some materials like fibre re-inforced plastics which have gained prominence as structural materials.

In reviewing the pattern of development under special materials it was observed that over the years expertise has been developed in the associated process technology. Indeed, the time now is more than over-ripe for further intensification of RDD activity in this area so as to cover a much wider range of related items. The present requirement for these items is being met, by and large, through import. The assessment also stressed that engineering aspects required to productionise these process technology must be strengthened considerably. The lack of significance attached, so far, to this evidently important area is all the more surprising when one notes that raw-materials for most of these items are available within the country, and that the required indigenous technological skills were also available at hand. Indeed, we have been traditionally exporting mica and manganese ore, only to import the finished products, based on them, to meet our economic requirements. The technology for electrolytic manganese metal and electrolytic manganese dioxide has been indigenously developed, and has been available for some time for commercial deployment. The technology associated with mica products is labour-intensive in character and RDD activity in this area demands attention.

The RDD project, proposals falling under this sector may be presented in six categories.

Category I

The projects falling under this category are presented below. The common features of these projects are:—

(i) The raw-materials for these items are available indigenously.

(ii) Expertise exists within the country.

(iii) The present requirement for these materials are primarily met through import.

The objective of these projects falls under one or more of the following.

(a) Extension of parameter range to locate the process parameters suited to a wider and newer range of user requirements.

(b) Emphasis on engineering aspects required to productionise the developed process technology.

(c) RDD activity required during up-scaling for commercial deployment.

The projects/programmes oriented towards electronics are as follows:

Alumina Ceramics

Electronics Ceramics

The objective of both these projects is to arrive at the process technology for the principal ceramic items useful as insulators, substrates etc. in electronics industry. Batch-production of these ceramics would be undertaken.

Ferroelectric and Piezoelectric Ceramics

Ultrasonic Transducers

The materials covered here are useful in micro-electronics, ultrasonic devices etc. The second project is directed towards the designing & fabrication of ultrasonic devices. Although the process technology has already been developed it has to be extended to cover a new range for these materials.

Ceramised Glass

Ceramised glass is reported to be one of the most outstanding of recent discoveries, a stake has been claimed for it as a new universal material rivalling metal, and to be used for such diverse products like ball-bearings, substrates in electronics, construction materials etc. The present project aims at achieving controlled crystallization of glass and to investigate its properties for printed electronic circuit boards.

Hydrothermal synthesis of quartz

The quartz crystal is not available in its natural form in this country, however, from available raw-materials it has been synthesized. It is used in oscillators, filters, etc. in the electronics industry. The present project pertains to RDD activity towards commercial production.

The two projects given now may be placed under electric furnaces.

Transparent Quartz Tube

The material finds use in steel making by electric resistence heating, and electric arc melting. It is reported that only 12 factories in the world are manufacturing this material. The present project is concerned with the engineering design aspects for the production of quartz tubing and aims at pilot-plant development suited to small industry.

Silicon Carbide heating elements

Silicon Carbide as a heating element is used in electric furnaces in the laboratory and industry. The aim of the project is to arrive at the process know-how for this material.

The remaining three projects are related to Refractory Materials.

Silicon Carbide abrasives and refractories

RDD for productionising.

Hexagonal Boron Nitride

The boron nitride is utilised in vacuum-furnaces for the preparation of high purity non-ferrous metals. It is also used as a solid lubricant. The project aims at laboratory scale production of this material.

ilicon Nitride sintered and hot pressed

The aim is to discover the process technology, and prepare shapes having the desired roperties.

ategory II

The projects related to photo materials fall under this category.

uminescent Materials

The principal demand is for photo luminescent materials and cathode-luminescent materials for mercury discharge lamps, fluorescent tube lights, television & picture tubes etc. It has een observed that recently some tube light manufactures have started making the required aterial, phosphor, through foreign collaboration. However, technological advances related o this material are very rapid, and it is essential that a firm RDD capability is established in he country. The project aims at developing indigenous know-how for the production of hosphor and further studies thereon.

hoto Emissive materials

The principal demand for this material arises from its use in photo-tubes and photomultiplier tubes. Our present demand is met entirely by import. The object of this programme is to develop the process technology for the preparation of a number of photocathodic materials.

hoto conducting materials

The material here find application in a large number of light-sensitive devices of common occurrence, and are used in laboratory and industry. Expertise in this field already exists within the country. The aim of the project is to diversify this capability so as to develop large-area photo-cells and infra-red sensitive cells.

Laser Materials

Lasers may be used in survey activity, range finding, medical application, meteorology, research, and industry. The effort thus far has been sub-critical in this area. The present project intends to develop the process technology associated with the various laser material.

Fluorescent material for paints and ink.

We are meeting our present requirements for fluorescent paints and ink through import. The project shall develop the required technology indigenously.

Category III

The programme on thin/thick film materials contains the projects listed below :

Thick film resistors with silver conducting pastes.

Special coating materials.

Process technology for Thick Films.

Tin Oxide resistors and potentiometer.

Semi-conducting Oxide films by plasma spray

Thick film technology is rapidly securing a major role in mocro-electronic industry. This technology involves low capital investments and operating costs, large-scale production is also easier. This technology, particularly, holds a great promise for our scale of application. This technology is of obvious significance in the field of space, and can be applied to items like radio and television resulting in considerable cost reduction. Similarly, thin films are also of interest in micro-electronics. The projects stated above focus on developing suitable materials for thick/thin films. One of the projects aims at developing the technique for depositing the materials on suitable substrates.

Category IV

The programme relating to Ferrites and Other Magnetic Materials consists of the projects listed below.

Strontium Ferrities Celestite Ore found in South India.

Development of Soft Ferrites.

Computer Memory Cores.

Gamma Ferric Oxide.

Rare Earth Cobalt Alloys.

Ferrites are a unique group of ceramic materials with magnetic properties usually associated with certain metallic alloys, and other properties far superior to these alloys. Ferrites find application in microwave tele-communication, computer memory cores, television an radio receivers, magnetic recording tapes etc. The ferrites for radio application have alread been developed within the country, and expertise is available in this area of technology. Th programme aims at diversifying and building up the technological capability to produce th newer range of ferrite items, at present being imported. The development of strontium ferrite from indigenous raw-material, for instance, will import-substitute nickel and cobalt in microwaves tele-communication.

Category V

In this category nearly 18 projects go towards the formulation of the programme for th development of the fibre reinforced plastics technology. The programme covers the development of suitable fibres like 'S' glass and carbon fibres, boron and ceramic fibres, as well a high purity silica and alumina fibres. The programme also includes the development of epox resins, harders etc. Furthermore, projects have been included which relate to the development of moulding techniques for making FRP products. Provision has also been made f the training of technicians and craftsmen to familiarise them with this new technology. It ma be mentioned that the moulding of FRP products is fairly labour-intensive, and maintenan can be done with simplicity and ease.

A number of projects falling under this programme are assisted through UNDP, the foreig exchange component coming from UNDP has not been included in the sectoral demand.

Category VI

The mica products development programme has been suggested bearing in mind that t demand abroad for our mica-ore has slackened by virtue of the entry of synthetic replacemen It may also be noted that much of our mica products requirement, especially for the hea electricals industry, is met by import. Despite the introduction of synthetic replacement abroa mica has certain attractive features which as yet cannot be met by them. The production fabricated mica, and manufactured mica are particularly labour-intensive activities. Keepi these factors in mind it is of primary importance that we undertake RDD work so as to be able to meet not only our needs but through product diversification create an export potential.

Miscellaneous

For completeness attention may be drawn to two projects, one of which deals with liquid crystals, and the other on diversifying the existing capability in the carbon products technology. The financial outlay for the development of special materials is summarised below It may however be noted that the total RDD expenditure for the projects amounts to Rs. 15.85 crores out of which Rs. 1.76 crores is to be funded through development contracts from DST. The sectoral demand shown is therefore only about Rs. 14.00 crores.

Group	Qutlay (Rs. in lakhs)
Ceramics Quartz etc.	109.0
Mica	25.0
Electronic Mat.	500.0
Films	12.0
Photo Materials	44.5
Ferrites Etc.	35.5
Composite Materials	269.4
Carbon	3.0
Liquid Crystals	3.0
Centres	357.4
Basic Project Areas	45.0
Total	1408.8

The details of the projects identified by the various groups are given below:

Project Index No.	Title of the Project	Financial outlay (Rs. lakhs)
1	2	3
	Ceramics, Quartz and Related Materials	
$S_{20}G_1P_1$	Alumina Ceramics	15.00
2	Electronic Ceramics	10.00
	(i) Porcelain	
	(ii) Forsterite	
	(iii) Cordierite	
	(iv) Mullite	
	(v) Magnesia	
	(vi) Zirconia	
	(vii) Wollastonite	
	(viii) Beryllia	
	(ix) Spodumene	
3	Ferroelectric & Piezoelectric Ceramics	12.0
4	Ultrasonic Transducers	10.0
5	Ceramized Glass	10.0
6	Transparent Quartz Tube	11.0
7	Hydrothermal Synthesis of Quartz.	39.0
8	Silicon Carbide Abrasives & Refractories	2.6
9	Silicon Carbide Heating Elements	6.0
10	Hexagonal Boron Nitride	0.4
11	Silicon Nitride, Sintered and Hot Pressed.	2.
12	Transistion metal carbide and nitrides for cutting tools.	2.0
	Mica	
$S_{20}G_2P_1$	Mica Products Development.	25.0
	Electoronic Materials	
$S_{20}G_3P_1$	Central Semi-Conductor Research Corporation (Proposed).	500.
	Thin/Thick-Film Materials	
$S_{20}G_4P_1$	Thick Film Resistors, with Silver Conducting Pastes	3.
2	Special Coating Materials (Mg, FZ, Zn, TiO, Cryolite, SiO2—)	2.
3	Process Technology for Thick Films	4.
4	Tin Oxide Resistors and Potentiometers	5.
5	Semiconducting Oxide Films by Plasma Spray	0.
	Photo Materials	
$S_{20}G_5P_1$	Laser Materials	20
2	Luminescent Materials	15.
3	Photo Emissive Materials.	6.
4	Photo Conducting Materials.	6.
5	Fluorescment Material for Paints & Ink	2.
	Ferrites & Other Magnetic Materials	
$S_{20}G_6P_1$	Strontium Ferrites Using Celestite Ore Found in South India.	12
2	Development of Soft Ferrites	10
3	Computer Memory Cores	8

1	2	3
5	Gamma Ferric Oxide	2.50
4	Rare Earth Cobalt Alloys	3.00
	Composite Material	
$S_{20}G_8A_1P_1$	Melting of Special Glass ('S' Glass) for High Strength Glass Fibres	11.65
2	Continuous Glass Filament Drawing Process Using Ceramic Bushings	2.59
3	Viscose Rayon as Precursor Material for Carbon Fibres	12.30
4	Know-how for Production of Carbon Fibres using PAN & Viscose Rayon precursor.	9.55
5	Process Development for Production of Continuous Fibres of Carbon	0.98
6	Carbon Composites Products for Aero-Space Etc.,	13.53
7	Boron & Ceramic Fibres Composites	17.05
8	Development of High Silica & Alumina Fibres & Pilot Plant Studies To Productionize	7.30
$S_{20}G_8A_2P_1$	Indigenous Development & Production of Epoxy Resins, Hardeners, & Associated Products.	30.00
$S_{20}G_8A_3P_1$	Development & Production of Electrolytically Pure Copper Foil with Compatible Chemical coating for Lamination with epoxy Glass in continuous foil form.	25.00
$S_{20}G_8A_4P_1$	Production of Composites (W-Ag, W-Cu, Ag-Ni, Ag-Cdo)	5.00
2	Metal Composites	5.00
$S_{20}G_8A_5P_1$	Development of Technique for making FRP Transport Containers, Columns for Chem, Ind., Automobile Bodies, Silos, etc.	30.00
2	FRP Materials for Electronic & Electrical Industry.	50.00
3	FRP Materials for Marine Applications	25.00
4	Establishing of High Pressure Moulding Facility	50.00
$S_{20}G_8A_5P_1$	Training in Composite Tech. Materials Technology..	25.00
$S_{20}G_8A_7P_1$	Development of Testing facilities & Evolution of Standards & Testing procedures for FRP Products	40.00
	Carbon Products	
$S_{20}G_9P_1$	Carbon Products	8.00
	Liquid Crystals	
$S_{20}G_{10}P_1$	Liquid Crystals	8.00
	Materials Research Centres	
$S_{20}G_{11}P_1$	Crystal Growth Centres	100.00
2	Centres for Characterization of materials for Purity & Perfection	50.00
3	Centres for Standard Reference Materials	10.00
4	Centres for High Pressure Facilities	20.00
5	Centres for Testing Bio-Materials	12.00
6	Preparation of Bio-Materials	3.00
7	Material Research Institute (Proposed)	200.00
	Basic Project/Areas	
$S_{20}G_{12}P_1$	Electronic Ceramics	3.00
2	Ferroelectric & Piozoelectrie Ceramics	5.00
3	Ceramized Glass	2.00
4	Electronic Materials	20.00
5	Mica	2.00
6	Thick/Thin Film Materials	2.00
7	Photo Materials	10.00
8	Magnetic Materials	10.00
9	Composite Materials	10.00
10	Liquid Crystals	1.00
11	Superconducting Materials	5.00

SECTOR—MACHINE TOOLS

197—198

chine Tools

Machine tool technology requires special emphasis in the bid towards self-reliance and elerated technological build up, because it is a 'Mother Technology' which provides the ion essential tools that generate production in almost all sectors of its economy.

The leap forward in technology and consequent industrial progress depends largely on the enuity that the nation can bring to bear upon its machine tool building industry year after r. High productivity, lowering of costs of manufacture, and support of newly emerging ovations/processes in all other fields of science and technology are subservient to the availlity in the country of matching competence in machine tool design, development and manuture. It is for this reason that the machine tool industry receives a very large proportion of RDD budget in advanced countries.

Machine tool industry thrives on innovations and early technological progress. In India, wever, the indigenous machine tool manufacturers have had very few innovations to offer m year to year, and by and large, the same old collaborators drawings have been used thout improvement. As a result of this, fresh demands for the latest machines have had be met through repetitive imports from various countries in the world.

A large part of the indigenous capacity built up in this field has resulted only through eign collaborations. In this process, there has been a lack of recognition of the necessity absorption of the underlying technology, in spite of the fact that adequate capacity exists t only for absorbing the associated technology but also for making further improvements d developments thereon.

As a consequence of this lack of design and development activity in this industry:

(a) Employment of a large number of designers, engineers and skilled workers is denied;

(b) Increase in productivity and lowering of costs do not occur, affecting adversely the consumer ultimately; and

(c) Imports continue while Indian capacity, Indian engineers and Indian technicians remain idle.

The installed capacity in machine tools is for production in excess of Rs. 70 crores nually. Against this, the 1970 production was Rs. 37.23 crores. Yet, the value of the achine tools imported during this period amounted to Rs. 18.30 crores. The export was ly Rs. 3.20 crores in 1970. Machine Tools are amongst the best items for engineering port for India, because they include large technical content as well as labour added value. dia stands an excellent chance to compete abroad if due emphasis on quality and indigenous genuity is laid from now on.

In addition, it has been identified that the 250,000 metal cutting machine tools presently stalled in India are utilised at only 40% of their potential capacity, giving a production of s. 3000 crores in value. Full potential utilisation of these machine tools could thus add any crores of Rupees to the country's net domestic product. An equitable distribution of e gains from increased productivity could mean a 6% reduction in consumer prices of manuctured goods, and 33% increase in salaries and wages of employees in manufacturing indus- es.

As a result of the large amount of technology that has been imported into the count over the years, Indian know-how has become all the more rich, and Indian talent is now poise to undertake indigenisation of a large number of machine tools.

The foremost aim of all RDD activities in the machine tool sector is to develop tec nological competence to match indigenous engineering and process technologies, as and whe required along with the ability to manufacture matching machine tools. This will accelera India's emergence as a nation able to compete with any nation in technologies that shall b current and appropriate.

With these objectives in view the national technology plan for machine tools was prepare by the NCST Panel on Machine Tools in consultation with approximately 170 expert in th field.

The following reports have been prepared by the working groups in the Machine Too sector :

1. Foundry machinery
2. Forming machinery
3. Material removal machinery
4. Joining machinery
5. Heat treatment equipment
6. Measuring and testing equipment
7. Plastics machinery
8. Modernisation of machinery
9. Productivity of machine tools
10. Defence production machines
11. Export potential and strategy
12. Information and documentation in machine tools
13. Metal working and metal forming tools, including hand tools.

In addition Detailed Project Reports have been received for four of the fifty competen oriented machine tools identified for development under the national S&T Plan for machine too The reports are for development of :

1. Electro Discharge Machine
2. Numerically Controlled Lathe
3. Vertical Machining Centre, Auto Tool Changer and Precision Index Table
4. Front Automatic Chucking Lathe

A report has also been received on the need for development of RDD capabilities in t automobile tyre industry.

The most urgent developmental requirements have therefore been identified and RD projects recommended for bridging the existing technological gaps and for the creation of sound base as a means of self-reliant economy. These have been covered both as short a ng term programmes and are intended to act as propellants to the accelerated growth of indus-y in the country.

Thirteen planning groups have been set up under this panel. Machine tool technology covers quipments for carrying out six basic processes *viz.* Founding, Forming, Cutting, Joining, Ther-al Treatment & Measurement. The specialist integrated group have worked out technology plans r each of these sectors. In addition specialist groups have also been created to give particular tention to defence production machine tools, modernisation and upgrading of the existing nge of indigenously produced machine tools and increase of productivity of existing quipment. Supplementary groups have also been created to cover plastics machinery, and formation, codification, documentation in machine tools. 31 RDD projects have been entified for implementation during the Vth plan involving a financial outlay of Rs. 57.04 ores.

The existing investment in machine tools is of the order of Rs. 1100 crores. The total DD activity on such a huge investment has so far amounted to a negligible amount. The Vth lan envisages the setting up of new institutes, for carrying out organised activities on a ontinuous basis since the rate of obsolescence and development of new machining processes very high leading to ever more economical production methods which justifies great emphasis n machine tool research.

The projects identified in this sector can be classified into projects for strengthening RDD cilities in public enterprises and creation of new RDD organisations and facilities. Since e nuclei already exist in some public sector units like HMT, CMTI, NML, CMERI etc. r RDD activities, augmentation of these facilities will yield rapid results. New organisations ave been proposed in areas where there is negligible indigenous expertise or no organised or urposeful activity. These include the establishment of a foundry research institute, a design stitute for forming machinery, an institute to undertake RDD in welding equipment and onsumables, an institute for heat treatment technology, a hand tools institute, an institute to ndertake RDD in abrasives etc.

Amongst the new organisations to be set up in the Vth Plan, of special significance is e proposal identified by the group on Joining Machinery (welding equipment and consum-bles), which has revealed a complete lack of RDD infra-structure capable of handling the evelopment, design and prototype work in process, equipment and consumables fields. In is connection BHEL has been identified as the implementing agency in co-operation with HPVL, TSL & Hindustan Shipyard, for the establishment of a welding research institute. HEL is already processing a proposal for the establishment of a welding research institute ith UNDP assistance at Trichy. The scope of this Institute should be widened to cover the bjectives identified by the NCST. The total value of structures to be welded during the fifth ve year plan is of the order of Rs. 2000 crores. The total financial outlay for the establish-ent of the welding research institute is Rs. 16.73 crores, which is less than 1% of the total alue of structures to be welded.

Also of vital importance to the nation's economy is the development of various strategic nd competence oriented machine tools which have been identified under the National S&T lan for machine tools. This includes the development of Numerically Controlled Machines, pecial Optics, Magnetic Tape Control and other sophisticated items for machine tools and esting equipments. The primary aim within the time period of 5 to 10 years would be not nly to close, by and large, the technological gaps with the advanced countries, but in certain elected areas to take Indian ingenuity beyond that of its competitors, which is feasible with ell identified programmes, provided adequate support is given to the developmental agencies. n some selected fields Indian machine tools must attain a leading position.

The developmental costs that will be incurred for the implementation of the National S& Plan for fifty machine tools has already been approved.

Rs. 1500 lakhs has been indicated for development of certain special machine tool ite such as lasers, ultra-sonic machines, precision grinders, jig borers etc., in HMT/CMTI. Out this amount, Rs. 750 lakhs have been included by HMT in their plans put up to the Ministry Heavy Industries.

RDD work in the field of measuring instruments and testing equipment is required chie from the point of view of import substitution. The development of raw materials needed the manufacture of these instruments include materials such as beryllium copper, phosph bronze, special steels etc., for which projects have been formulated.

There is also a great awareness of the importance of foreign trade and export promoti India ranks 16th among the world's 30 main machine tool producing countries (based on sta tics for 1970). Her negligible export, however, brings down the rank to the 22nd place. proposals chalked out by the working group covering the aspects of export promotion oriented towards achieving rapid growth in this sphere, improving India's position among machine tool exporters of the world. India stands an excellent chance to export in la quantities machine tools, which are labour intensive, since labour costs are low in In Hence accelerated growth in RDD would enable Indian machine tools to earn foreign excha in a large measure.

In addition it would provide employment to about 1200 persons.

A broad picture of the programmes under each planning group is given below :

Foundry Machinery

Two programmes have been identified in this sector. The first envisages the establ ment of a 'Foundry Research Institute' for initiating original RDD in the designing of found and foundry equipment. Keeping in view the developments that are taking place in the f of foundry machinery in the advanced countries, to meet the growing challenges of new cesses, enhanced requirements of strength, quality, dimensions, surface finish etc., and in o to increase the progressive indigenous manufacture of items such as induction furnances (gre than 1 T capacity), high pressure moulding machine, core-shooters, core-blowers, hydro-b equipment etc., which are at present being met by imports, it is imperative that such an i tute be established on a priority basis. In this connection it has been suggested that NIFFT (Ranchi) be upgraded to such a status at an estimated cost of Rs. 350 lakhs.

The second programme is for carrying out RDD in the CO_2 process for moulds for iron castings for the manufacture of rings, required for the underground tube railway projec Calcutta.

Forming Machinery

Metal forming machine tools are basic appliances which play a vital role in the indu A number of small and medium scale tool manufacturers are in a position to under manufacture of metal forming tools provided the drawings are made available to them. order to bridge this gap, it has been suggested that a metal forming tool design institute established.

Metal Removal Machinery

It has been found necessary that in the coming Five Year Plan, the country sho ake the development of those machine tools which have not been manufactured These include jig borers, jig grinders and machines required in the watch makin Also, taking into consideration the big need for precision machines such as those r he Defence, Aircraft and Space industries, it is essential that development of va non-traditional machines such as ECM, ultrasonic machines, lasers etc. be undertake

ools

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nachine

Joining Machinery

Welding has established itself as the most reliable method for joining of metals a Progress in almost all the fields of science and technology has been possible by in in joining machinery, consumables and technology, running closely parallel to the develc metals and alloys to meet increasingly exacting conditions of service which advanced tec and design in the fields of fabrication demand, starting from common materials to sophisticated special materials as required in the present day nuclear and space engineer importance of formulating, progressing and implementing a national plan for joining m consumables and technology needs hardly any emphasis.

vould
pro-
with
mers,

In the first four Five Year Plans, however, hardly any worth-while attention h given to this very important technology which finds a place in a small or large me every engineering activity.

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3

In the field of RDD, a limited effort has been made in the public sector private sector. The future development for advancement of joining machiner and technology, particularly in the specialised fields such as Electro-slag, MIC tron Beam, Laser welding techniques, Underwater welding and joining techn electronics, nuclear and space technology, has to be systematically planned order to bridge these gaps and to bring upto-date the industry in the pr welding technology, it has been suggested that one Central Institute ar centres be established in the country.

360.00
100.00
1500.00
1673.00
243.00
58.00
10.00
32.00

Heat Treating Equipment

The current demand for heat treatment equipment is about R expected to increase to over Rs. 10 crores/year during the 5th Pla capability is however based upon know-how accumulated in le considerable dependence on import of technology in the form part fabrication and accessories. Delivery periods are as ex the case of many large and more sophisticated furnaces. T R&D effort under way in the country at present.

Proposal included under
Planning group No. 12

230.00
40.00
200.00
943.00
525.00

To fulfil the long term objectives in the fie nology, it has been suggested that a separate accommodate definite programmes for cated design and technological aspects, nation of unsystematic import of tec indigenous know-how, based on p nologies by different firms from di

and Total 5704.00

and therefore not included in Grand Total for MachineTools.

fic problems of immediate importance involve gaps in the current indigenous avail
Th vacuum heat treatment furnaces, sintering furnaces, special atmosphere furnaces
Plan fo es), medium and high frequency heat treatment equipment (larger sizes), diffusion
for transistor industry), flame hardening equipment, the availability and quality
Rs ies, ancillaries and raw materials including special combustion equipment, hydraulic
such as strumentation and controls, alloy steel castings, gas generators etc. Therefore RDD
this am e areas mentioned above should be initiated. The cost is estimated to be of the
Heavy s. 45 lakhs.

R dition strengthening of the existing facilities at laboratories such as NML, NAL,
from t CGCRI etc., has also been proposed at a cost of about Rs. 43 lakhs.
the n
bronz *g Instruments and Testing Equipment*

the engineering industry precision measuring tools, gauges and instruments play an
India t role in the successful implementation of mass production, inter-changeability and
tics f . Unfortunately although an investment of the order of Rs. 10,000 crores has been
prop the engineering industries during the previous plan periods, there has been a serious
orier the development of measuring and testing equipments. Only a small percentage of
mac capacity has actually been utilised for the manufacture of production gauges, vernier
qua crometer instruments. Comparators, optical instruments and other special purpose
Here nts are not being manufactured in the country.
in

In a of the measuring instruments, particularly of the indicating types are being im-
he country. These include :

A broa precision dial gauges.
n block levels.
Foundry Mach
gauges.
Two progra
ment of a 'Foundr nd optical comparators.
and foundry equip ng machines.
of foundry machine
cesses, enhanced req easuring machines, etc.
to increase the progre
than 1 T capacity), hi ing made in various RDD institutions to design and develop some
equipment etc., which ar nstruments which are being imported currently.
tute be established on a
NIFFT (Ranchi) be upgra es of instruments for measuring and testing suffers from the
tage of the raw-materials. It has, therefore, been proposed
The second programme ided as development costs for these materials by various CSIR
iron castings for the manufactu essary also, that financial assistance be made available to
Calcutta. vate undertakings, and for the development of measur-
f the order of Rs. 30 lakhs.

Forming Machinery

Metal forming machine tools are basic app development cell' need be established for
A number of small and medium scale tool man rospective entrepreneurs and for under-
manufacture of metal forming tools provided the d r ultimate commercial reproduction
order to bridge this gap, it has been suggested that al is of the order of Rs. 18 lakhs.
established.

Plastics machinery

In India, today, there is no centre that provides information in the field of rubbe and high polymers in general. In order to provide Indian scientists, engineers, e ndustrialists and students with the latest information on world developments in high he group has identified the importance of establishing a 'Documentation and Di: Centre' covering the polymer industry.

ols

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nachine

Modernisation of machinery

Efforts are required in improving the quality of machine tools for consistent pe. and accuracy and for this, proper manufacturing know-how, and facilities are required of the cost factor, many units in the small scale sector are unable to afford this. It has been suggested that common facility centres, equipped with sophisticated machinery, be o serve the industry. In addition, they will also provide design know-how, and would process sheets. The total cost would amount to Rs. 24 lakhs. Secondly, in order t) pro- he correct acceptance procedures for machine tools, which would lay down guidelines with buying organisations to evaluate machines for their requirements, a sum of Rs. 8 lakhs omers, ndicated.

Productivity of machine tools

The group has carried out an exhaustive survey on the machine tools in the cou has recommended various in-house methods to increase the productivity in order t a greater industrial growth rate and freer supply of industrial products while simu reducing the cost.

Defence production machines

It has been pointed out that facilities for manufacture of shells, guns, smal nunition are available in the country and indigenisation in these fields will im competence while saving scarce foreign exchange at the same time. Ther been drawn up for the manufacture of machine tools, required for the ite The total financial outlay is about Rs. 210 lakhs. A special R&D C special purpose tools has also been proposed involving a further expendit

Export potential & strategy for machine tools

The percentage of machine tool exports to the country's tota running at a very low level of hardly 6 per cent. As compared to th of machine tools of 20 to 25 per cent of the total indigenous pr far has been poor.

If exports of machine tools are to reach a respectable adopt many non-conventional and ingenious methods and reach substantial volume, we should turn to the export machine tools, and licence our designs and know-h countries. This may sound ambitious but is not ir

In any highly industrialised country, t of the total requirements. But this is m export its machine tools at least to the were no tangible exports of machine t

Outlay (lakhs)
3
360.00
100.00
1500.00
1673.00
243.00
58.00
10.00
32.00
Proposal included under Planning group No. 12
230.00
40.00
200.00
943.00
525.00
5704.00

nd Total

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and therefore not included in Grand Total for MachineTools.

ustry and the Government in this respect till 1965-66, perhaps due to their concen-
Tl
Plan fc ubstitute imports by indigenous production to the maximum extent possible. However,
ere have been concentrated efforts made by both the Industry and the Government
Rs exports of machine tools. Several incentives and market facilities have been
such as the industry by the Government.

this am er to study the new technological developments in machine tools, the trend in demand
Heavy , the group has recommended the setting up of an 'Export Cell'. The Cell will also
elf with the collection of data regarding specifications, special features and price
R opularly required machine tools in the international market. The financial outlay is about
from khs. It has also been suggested that the Government should encourage the setting up
the r entures abroad in the countries that need simple machine tools of the type that can be
bron . and manufactured by Indian know-how, and the establishment of finishing and
plants abroad to meet the requirements of the foreign customers. The cost is
to be Rs. 20 lakhs.

India
tics *ion codification, documentation in machine tools*

prop noted that the country does not have a technical press of any large standing and
orie technical information services are at best functioning in name only. It is, therefore,
mac that a 'National Information & Documentation Centre' be established to collect,
quac ranslate and disseminate world literature on machine tools and production engineering.
Heien
in *ng and metal forming tools, including hand tools*

In aps in this sphere are largely to be bridged through institutional RDD. The group
nded the setting up of various institutes for RDD in metal cutting tools, metal
hand tools and abrasives. It has also identified certain special purpose tools that
A broo ed in the country by both private and public concerns. In addition, a coordina-
'v 'Indian Manufacturing Tool Research Association' (IMTRA) needs to be
Foundry Mach that the fruits of all these RDD efforts are made available to all.

Two progra
ment of a 'Foundi
and foundry equip
of foundry machine
cesses, enhanced req
to increase the progre
than 1 T capacity), hi
equipment etc., which a
tute be established on a
NIFFT (Ranchi) be upgra

The second programme
iron castings for the manufactu
Calcutta.

Forming Machinery

Metal forming machine tools are basic ap
A number of small and medium scale tool ma
manufacture of metal forming tools provided the
order to bridge this gap, it has been suggested tha
established.

ADDITIONAL PROJECTS

mergency funding for development of 50 machine tools as per NCST plan on machine tools

The total cost of development of 50 machine tools is estimated to be Rs. 325 lakhs. These achines are competence oriented and are of strategic importance for development of machine ools and technology in the country.

stablishment of RDD centre for the automobile tyre industry

It is necessary that a major RDD efforts be mounted forthwith in this field. This would eal with all aspects of tyres, from basic materials to design, field trials, etc. It would also provide testing facilities for tyre development. In addition, it would have strong links with PCL and other organisations which have much to contribute in the development of elastomers, re cords, adhesives etc.

The outlay proposed by the Planning groups are as follows.

.No.	Planning Group	Financial Outlay (Rs. in lakhs)
1	2	3
1.	Foundry Machinery——Cast Iron, Cast Steel etc.	360.00
2.	Forming Machinery——Bending, Rolling, Forging etc.	100.00
3.	Material Removal Machinery—Cutting Grinding, Punching, Shearing etc.	1500.00
4.	Joining Machinery——Brazing, Soldering, Welding etc.	1673.00
5.	Thermal Treatment Equipment——Furnaces, Heaters etc.	243.00
6.	Measuring Instruments & Testing Equipment—Metrology, Mechanical, Electrical etc.	58.00
.*	Plastics Machinery——Equipment for Forming & Shaping Plastics & Polymers, Die casting.	10.00
8.	Modernisation of Machinery.	32.00
9.	Productivity——Increasing Productivity of Existing Equipment	Proposal included under Planning group No. 12
0.	Defence Production Machine of Specialised Nature	230.00
1.	Export Potential & Strategy for Machine Tools	40.00
2.*	Information Codification, Documentation in machine Tools	200.00
3.	Metal Working & Metal Forming Tools including Hand Tools.	943.00
4.	Additional Projects	525.00
	Grand Total	5704.00

*Transferred to 'National Information System' and therefore not included in Grand Total for MachineTools.

Projects identified by the various planning groups are as given below—

Project Index No.	Title of Project		Financial Outla (Rs. in lakhs
	Foundry Machinery		
$S_6G_1P_1$	R & D in suitable process for manufacture of grey iron cast rings for underground tube railway project at Calcutta.		10.
P_2	Establishment of a Foundry Research Institute.		350.
		TOTAL G_1	360.
	Forming Machinery		
$S_6G_2P_1$	Establishment of a Design Institute for Forming Machinery at Bombay.		100.0
		TOTAL G_2	100.0
	Material Removal Machinery		
$S_6G_3P_1$	Development of sophisticated Material Removal Machine Tools.		1500.0
		TOTAL G_3	1500.0
	Joining Machinery		
$S_6G_4P_1$	Establishment of one Central Institute and 4 other Regional Centres for RDD in joining Technology		1673.0
		TOTAL G_4	1673.0
	Thermal Treatment Equipment		
$S_6G_5P_1$	Strengthening of existing R & D facilities at various laboratories.		43.0
2	Process & Equipment design development in the fields of: (a) Vacuum Heat Treatment. (b) Sintering Furnaces. . . . . (c) Medium/High Frequency Heat Treatment Equipment. (d) Flame Hardening.		45.0
3	Establishment of a new facility for Heat Treatment Technology. . .		155.0
		TOTAL G_5	243.0
	Measuring Instruments & Testing Equipment		
$S_6G_6P_1$	Development of Raw Materials for Instrument Manufacture.		10 .
2	Assistance to the industry for manufacture of gauges, measuring tools and instruments.		20.0
3	Development of Measuring instruments by the private sector.		10.0
4	Establishment of a cell for development of precision measuring instruments.		18.0
		TOTAL G_6	58.

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*Transferred to 'National Information System' & therefore not included in Grand Total for Machine Tool sect

1	2	3
	Plastics Machinery	
G_7P_1	Establishment of a Documentation & Dissemination Centre covering the Polymer Industry.	10.00
	TOTAL G_7	10.00
	Modernisation of Machinery	
G_8P_1	Setting up of common facilities for the manufacture of machine tools at Coimbatore, Rajkot, Calcutta & Ludhiana & supply of technical process sheets to the industry.	24.00
P_2	Evaluation of Machine Tool Qualities & acceptance.	8.00
	TOTAL G_8	32.00
	Increasing Productivity of existing equipment.	
	PROPOSAL INCLUDED UNDER WORKING GROUP NO. 12.	
	Defence Production Machines of Specialised Nature.	
$_6G_{10}P_1$	Development of machines for Shell manufacture.	18.50
2	Development of machines for Gun manufacture.	123.00
3	Development of machines for Small Arms manufacture.	50.00
4	Development of machines for Small Arms Ammunition manufacture. . . .	18.50
5	Establishment of a Special R & D Cell for development of special purpose tools.	20.00
	TOTAL G_{10}	230.00
	Export Potential & Strategy for Machine tools.	
$G_{11}P_1$	Setting of an 'Export-Cell' for machine tools.	20.00
2	Joint ventures abroad for machine tool manufacture.	10.00
3	Setting up of finishing & assembly plants abroad for machine tools. . . .	10.00
	TOTAL G_{11}	40.00
	Information Codification, Documentation in Machine Tool.	
$S_6G_{12}P_1$	Establishment of 'National' Information & Documentation Centre for machine tools.	200.00
	TOTAL G_{12}	200.00

1	2	3
	Metal Working & Metal Forming Tools including Hand Tools.	
$S_5G_{13}P_1$	Establishment of a 'Metal Cutting Tools' Institute at Bombay.	220.00
2	Establishment of a 'Metal Forming Tools' Institute at Hyderabad. . . .	230.00
3	Establishment of an 'Abrasives Institute' at Madras.	183.00
4	Establishment of a 'Hand Tools Institute' at Faridabad.	145.00
5	Formation of IMTRA (Indian Manufacturing Tools Research Association).	125.00
6	Development of special purpose tools.	40.00
	TOTAL G_{13}	943.00

ADDITIONAL PROJECTS

1	2	3
1.	Funding for the development of 50 machine tools as identified under the emergency S & T Plan for machine tools. . .	325.00
2.	Establishment of an R & D Centre for the automobile tyre Industry. . . .	200.00
	TOTAL	525.00

Foundry Machinery

Development of suitable process for manufacture of grey iron cast rings for underground railway project in Calcutta

The underground tube railway organisation in Calcutta has been negotiating with HEC for production of a large number of grey iron cast rings for the tube railway. These rings are several meters in diameter and are comparatively thin walled castings requiring a considerable amount of developmental effort. If these rings are not developed and manufactured in India, almost the entire quantity may have to be imported.

HEC proposes to develop the technology for manufacture of these rings using the carbon-dioxide process for moulds, at a reasonable cost and to achieve a fast rate of production. In view of the urgent requirements of the tube railway, this project is to be taken up on top priority basis.

Total financial outlay : Rs. 10 lakhs.

Establishment of a Foundry Research Institute

The starting point for initiating original research and development in foundry machinery is research and development in the foundry itself. In advanced countries, this work is being done by Foundry Research Institutes run independently and financed by Government or manufacturers associations or run as departments of big manufacturing units. These institutes are responsible for a large number of developments in the field of foundry industry and subsequently in the foundry machinery and equipment industry. India is lacking in this field as there is not even one foundry research institute, and steps need be taken to correct the situation immediately. It is, therefore, suggested that the NIFFT be upgraded to include research and development in the field of foundry equipment etc. Other functions of the Institute will also include the collection of statistical data regarding various types of foundries for utilisation in the design of new foundries.

Total financial outlay : Rs. 350 lakhs.

Forming Machinery

Establishment of a design institute for forming machinery

Metal forming machine tools are basic appliances which play a vital role in industry to maintain the high volume of production in mass production industry. High quality production in tool rooms and versatile applications in the small wayside workshops are of vital importance to the industrial growth of a country, forming a basic input for productivity to optimise the utilisation of men, machines and materials. Potential manufacturing capacity for metal forming tools exists in the country. A number of small scale and medium scale machine tool manufacturers are in a position to undertake manufacture of metal forming tools, provided the drawings are made available to them. In order to bridge this gap in tool design, it is necessary to establish a design institute that will have the important function of providing tooling design for modern metal forming processes.

Total financial outlay : Rs. 100 lakhs.

Material Removal Machinery

Development of sophisticated material removal machine tools such as jig borers, jig grinders, watchmaking machinery etc.

There is a big need for tool room equipment and precision machines. These machines include thread grinders, precision lathes, precision grinders, gear finishing machines etc. CMTI HMT and some other manufacturers have undertaken to develop some of these machines. On a long term basis, steps will be taken for development of machines such as jig borers, jig grinders, machine tools required for inspection and for the watchmaking industry. The development of advanced machining methods required for general engineering purposes as well as those required in defence industries, aircraft production and space engineering and development of NC machines and systems, will also be introduced. Work on production engineering and manufacturing aspects such as group technology, progressive cutting tools, machining methods of some of the exotic materials and the evaluation of machines on the basis of sustained performance will be undertaken. Development of the necessary processes and methods for manufacture of spindles, bearings, guideways etc., and of non-traditional machines such as ECM, EDM, ultrasonic machines, lasers, etc. will also be taken up as basic research problems for eventual development of production machines.

Total financial outlay : Rs. 1,500 lakhs.

Joining Machinery

Establishment of a Central Institute and four other regional centres for RDD in welding equipment and consumables

A total or near total gap exists in the country, in processes having potential for high productivity and reduction of cost, application in specific fields such as sub-merged arc, electroslag, TIG. MIG welding etc. Manual metal arc welding has taken more share than elsewhere in the world. Modern and sophisticated processes are conspicuous by their absence. Among the automatic and semi-automatic welding processes, while submerged arc welding has been adopted to some extent, MIG welding has made little progress due to non-availability of indigenously produced equipment. Such processes which have special fields of application particularly in strategic industries such as electronics, nuclear and space engineering need be given the most urgent attention. However, there is a complete lack of RDD infra-structure capable of handling the development, design and prototype work in process, equipment and consumable fields. It is therefore imperative to establish an autonomous RDD infra-structure to bring up to date the industries in the proper application of welding technology and liaison with industries to render them assistance in testing and training of operators, consultation and quality control services, design and prototype testing services etc.

With the progressive adoption of advanced technology in various industries, specialised consumables in uneconomically small quantities are required to meet special material and service conditions. Where the consumables manufacturing industry is unable to cater to such needs, the RDD organisation will undertake to develop and make available the consumables. Therefore to provide continuing support on a national basis for developmental efforts, it is imperative to establish a central institute to carry out RDD related to welding technology. Establishment of a close link between the industry and the central institute will itself provide the subjects for long and short term research, development and design work suited to our conditions. Such an institute should be established in the vicinity of a user organisation (manufacturing unit) for trials and development.

However, in a vast country like India, establishment of one Central Institute devoted to all the necessary activities will not be able to fulfil the primary objectives of establishing a very close link with the industry. To achieve this objective, regional centres in important areas where welding is extensively used as a tool are to be established.

Total financial outlay : Rs. 1673 lakhs

Heat Treatment Equipment

Strengthening existing facilities for heat treatment at various laboratories

In order to make a beginning in filling some of the gaps and also to initiate the building up of a firm foundation in the field of heat treatment technology, it is necessary that urgent and immediate steps be taken to strengthen RDD facilities and set up testing facilities for heat treatment process technology with due emphasis on the design and engineering aspects, at laboratories where the existing infrastructure can be extended by the creation of cells of expertise. These cells will ultimately form the basis for a central and highly specialised facility for RDD in heat treatment technology and equipment design. Laboratories requiring strengthening have been identified. These include NML, NAL, CMERI, CFRI etc.

Total financial outlay : Rs. 43 lakhs.

Process and equipment design development in the fields of :

(i) *Vacuum heat treatment*
(ii) *Sintering furnaces*
(iii) *Medium/High frequency heat treatment equipment*
(iv) *Flame hardening.*

The current combination of unsystematic import of technology as drawings or for part fabrication of components for acquiring know-how, has led to a proliferation of similar technology by different firms from different foreign countries. This has led to problems of spares and accessories due to the varying specifications for similar items. It has also led to the import of technology already obsolete and in the process of being discarded in the country of origin. In the fields enumerated above it is necessary to formulate projects to meet the needs of the Vth Five Year Plan. The indigenous status of technology is almost nil and only existent to the extent of imported furnaces in operation in the country, whereas foreign technology has attained a rather high level of sophistication. The RDD efforts will involve process and equipment design development in all cases.

Total financial outlay : Rs. 45 lakhs.

Setting up of a new facility for heat treatment technology

To fulfil the long term objectives in the field of the development of heat treatment technology, a separate and specialised facility need be planned and set up. The current demand for heat treatment equipment is about Rs. 4.5 crores/annum and is expected to increase to over Rs. 10 crores/annum during the Vth Plan. There is considerable dependence on import of technology in the form of drawings or in the form of part fabrication and accessories and delivery periods are very long in the case of many large and more sophisticated furnaces. There is no organised or definable RDD effort underway in the country at present.

Therefore, if such a specialised facility is set up, the furnace technology can be developed in a proper way. The 'cells of expertise' being promoted at existing RDD laboratories will form the nucleus for the new full fledged facility.

Estimated financial outlay is about Rs. 155 lakhs.

Measuring Instruments and Testing Equipment

Development of raw materials for measuring instruments and testing equipment manufacture

In all cases of manufacture of measuring and testing equipments, the quality of the end product depends upon the quality of the raw materials. The problem of availability of basic materials for the manufacture of instruments/machines is a large one. Instruments made of carbon steels with a carbon content of about 1 per cent pose no problem since such steels are available in the country. However, current international trends are towards the use of stainless steels of special types, owing to their low maintenance costs in the long run. These materials are being imported at present. To be self-reliant in this field it is necessary to take up the task of development of special materials such as magnetic steels, ferrites, semi-conductors like oxides of selenium, silicon, tellurium, special alloys of copper and aluminium, platinum, rhodium, iridium, nickel, chromium, lead, zirconium, other rare earth metals, optical glass, special plastics, synthetic jewels etc.

Total financial outlay : Rs. 10 lakhs.

Assistance to industry for manufacture of gauges, measuring tools and instruments

A few firms in India have been licenced to manufacture measuring instruments. Know-how in the form of drawings and specifications, with processing details, have been purchased from foreign collaborators, but in many cases it has been found that the machines and equipment which are of specialised nature and costly, have not been procured and the licensed capacity has not been reached and in some cases no production has even started. Therefore, to meet the expected demand, the manufacturing companies which have already been licenced should reach the targetted licenced capacity. Indigenous capacity of manufacture need also be increased by giving fresh licenses to intending manufacturers to increase the current production figures in some areas and to include the manufacture of new items which have been identified. Financial assistance should, therefore, be provided to expand the activities in the existing public/private undertakings or for starting new enterprises.

Total financial outlay : Rs. 20 lakhs.

Development of measuring instruments in the private sector

Certain items of measuring tools, gauges and instruments have already been licenced for manufacture in the small and medium scale sectors. However, a bulk of the requirements, particularly of the indicating types are still being imported. Some attempts are being made in various RDD institutions to design and develop indigenously, such of the precision measuring instruments as are being imported currently. As a result of this, prototypes of a few measuring instruments have been made. Provided that the know-how by way of design etc. and financial assistance are made available to the small scale units, these units are willing to undertake manufacture. This will result in substantial foreign exchange savings.

Total financial outlay : Rs. 10 lakhs.

Establishment of a cell for the manufacture of precision measuring instruments

Manufacture of precision measuring instruments has yet to find its proper importance in the country, although the demand for these sophisticated items has vastly increased. Almost the entire requirements of the industry are met from imports. A substantial portion of the small scale industries in the engineering field, if not all of them, goes without proper measuring instruments, which leads to sub-standard products. The shortfall could surely be met by organising a few of the small scale industries or by creating fresh entrepreneurs, to take up the instrument manufacturing line. Obviously, adequate support through supply of know-how and training will have to be provided to the prospective entrepreneurs. The cell will therefore be specially assigned to undertake development of standard measuring instruments like Vernier Calipers (200 mm to 1000 mm), Vernier Height Gauges, Micrometers, Micrometer Heads, Dial Indicators, Comparators, Gauge Blocks etc., for ultimate commercial reproduction by S.S.I. sector and to extend facilities in practical and theoretical training of fresh entrepreneurs, technicians, engineers and skilled workers in manufacturing different precision measuring instruments. The estimated total expenditure is Rs. 18 lakhs with a foreign exchange content of about Rs. 8.8 lakhs, which is necessary for import of precision machine tools required for instrument manufacture. The prototypes manufactured during the development period will also be sold at a total cost of Rs. 3 lakhs approximately, thereby reducing the revenue expenditure.

Plastics Machinery

Establishment of a documentation and dissemination centre covering the polymer industry

Rapid access to information is the fundamental aspect of research, development and progress in any sphere of science. The Indian National Scientific Documentation Centre (INSDOC), New Delhi, and Bangalore, provide information to scientists in several fields and have proved beyond doubt that its services are vital to the national economy.

In the field of rubbers, plastics and high polymers in general, the services of INSDOC have not yet been established, and it is unlikely to be established within the next five years. Hence in India there is no centre such as INSDOC catering to the needs of the high polymer industry. High polymers now play a vital role in every branch of science and technology. Although the developing countries have shown that the sixties was the 'decade for high polymers', the impact of high polymers on India has not yet occurred. There is thus a technological gap between India and the developed countries. The first step in bridging this gap is to provide Indian scientists, engineers, economists, industrialists and students with the latest information on world development in high polymers. By providing this information, a rapid growth in the technology of high polymers in India could be envisaged which, in turn, would cut down the unnecessary import of know-how, and develop the Indian industry.

Total financial outlay : Rs. 10 lakhs.

Modernisation of Existing Machinery

Setting up of common facility centres for manufacture of machine tools, in various parts of the country, and supply of technical process sheets to small scale units

Today's concept of a 'modern' machine tool is one that is able to meet the present day demand of production both in quality and quantity, and it is not only the conception of the machine of accuracy that makes it modern. Efforts are therefore required in improving the quality of machine tools for consistent performance, and for this proper manufacturing know-how and facilities are required. Many of the units, particularly in the small scale sectors, do not have the necessary facilities for manufacture of machine tools. This is primarily because of the cost factor. For instance, except in well established factories, units do not have heat treatment facilities, gear grinding facilities, jig boring facilities and so on. Therefore, if the machines to be produced are to be of modern design, these features require attention. It has therefore been suggested that common facility centres equipped with specialised and sophisticated machines be established at Coimbatore, Rajkot, Calcutta and Ludhiana to serve such industrial units on a jobing basis. These centres will also provide design know-how, material specifications etc. Technical process sheets will also be a part of the documentation along with design know-how. Such a system of supply of know-how and the facilities for manufacture will help the manufacturers in production of modern machine tools, particularly units in the small scale sector.

Total financial outlay : Rs. 24 lakhs.

Evaluation of machine tool qualities and acceptance

The present system of machine tool evaluation which is based on geometrical accuracy and alignment is not adequate and it is not able to give a clear and complete picture of the quality of a machine tool. The production life, rigidity, performance, consistent accuracy etc. are not checked. The evaluation of machine tools from the standpoint of their performance characteristics, design features and life are to be undertaken in a systematic manner to evolve the acceptance procedures for machine tools. These could act as guidelines for the buying organisations to evaluate machines.

Total financial outlay : Rs. 8 lakhs.

Defence Production Machines

Development of machines for shell manufacture

It is necessary that self-sufficiency in the production of shell manufacturing machines should be attained in the country. Some types of machines for shell production are already being made by HMT (FAY Automatics and 'PILOTE' Copying Lathes) and Praga Tools (George Fisher Copying Lathes). Some other types such as vertical centering machines, pip removing machines, base recessing machines, base rivetting machines, grooving and waving machines, etc., which are specially meant for shell manufacture are not being made indigenously. A complete indigenisation will improve India's defence capability besides saving foreign exchange to the tune of Rs. 350 lakhs by way of import substitution.

Total financial outlay : 18.5 lakhs.

Development of machines for gun manufacture

The manufacture of guns involves use of general purpose machines as well as certain machines which are specific to the production of guns. Machines such as Heavy Duty Gun turning Lathes, Deep Hole Boring Machines, Profile Milling Machines (rigid type), are not at present available indigenously. Most of these machines, however, come under the heavy machine tools category and apart from the defence sector some of the machines have wide use in heavy industries also. An indigenisation programme will improve the country's defence capability and develop competence, besides saving foreign exchange to the tune of Rs. 500 lakhs.

Total financial outlay : Rs. 123 lakhs.

Development of machine tools for small arms production

Need is felt for a greater degree of indigenous capability in production of machines for small arms manufacture. In the coming years, in addition to the defence requirements, the need for sporting weapons also will have to be met. It is therefore, worthwhile to take up indigenisation of certain special machines. Facilities for manufacture are generally available and the need for any special facilities is not foreseen. The suggested action plan will improve the country's self-reliance in regard to machines of strategic nature, and develop the nation's competence in design and development besides saving foreign exchange to the tune of Rs. 190 lakhs.

Total financial outlay : Rs. 50 lakhs.

Development of machine tools for small arms ammunition manufacture

The machines used for small arms ammunition manufacture are of special purpose, requiring high production rates and close tolerances. These have special features such as automatic hopper feed, multi-station work tables, quick tool adjustment and safety provisions for automatic stoppage in the event of improperly oriented components. These machines are not, at present made in India. It is therefore, felt that some of the machines should be taken up for import substitution, since the general facilities, materials and equipment for manufacture are generally available. From the point of view of mechanism, these machines are not complicated, but they involve a high degree of workmanship and the use of proper materials. It should be possible to develop these in the country with a reasonable effort. A base already exists for a section of this machinery *i.e.* presses both single and double action, which for other applications are already manufactured in the country. The proposed action plan will (a) improve self-reliance in regard to machines of strategic nature (b) develop the nation's competence in design and development, besides saving scarce foreign exchange to the extent of about Rs. 75 lakhs, on a rough estimate, by way of import substitution. Savings on account of spares is also a consideration.

Total financial outlay : Rs. 18.5 lakhs.

Establishment of a special RDD cell for development of special purpose machine tools

The systematic study of the machinery requirements for the ordnance factories has highlighted the need for an institution/organisation for continual developing, planning, coordination and execution with regard to the indigenisation of special types of machinery, which may or may not be required in sizeable quantities, but are still vital.

It is relevant to state here, that almost all large-sized manufacturing establishments in the engineering industries have some sort of RDD cells and a machine fabrication facility, which are responsible for fabricating, manufacturing the special purpose machines required for their production units. It has been proposed, therefore that a similar facility as is existing in the other production establishments, should be constituted for the ordnance factories. to systematise the indigenisation efforts. The set-up could be named Central Design and Development Cell and could work under DGOF, although parts of the cell may be located in factories periodically depending on the nature of work. The main role of the set-up will be one of coordination.

Total financial outlay : Rs. 20 lakhs.

Export Potential and Strategy for Machine Tools

Setting up of an 'Export Cell' for machine tools

In order to study the new technological developments in machine tools, the trend in demand pattern etc., the establishment of such a cell consisting of designers, production technologists and commercial executives, is the imperative need of the hour. The cell will also concern itself with the collection of data regarding specifications, special features, accessories and price ranges of the popularly required machine tools in the international market and will equip itself with information and data on existing products manufactured in India, specially the items which are already being exported as well as those having export potential. It will also suggest modifications that have to be carried out in the existing products to suit the requirements of the export market.

Total financial outlay : Rs. 20 lakhs.

Joint ventures abroad for machine tool manufacture

Simple, standard, low priced machines with a variety of accessories and attachments suitable for training centres and small workshops, have a ready market in the developing countries. The Government should therefore, encourage the setting up of joint ventures abroad in the countries that need simple machine tools of the type that can be developed and manufactured by Indian know-how.

Total financial outlay : Rs. 10 lakhs.

Establishment of finishing and assembling plants abroad

Indian Machine Tool Manufacturers have found it difficult to sell machine tools fitted with indigenous electricals, accessories and attachments in the industrially advanced countries. It is, therefore very necessary to set up abroad, facilities to procure such electricals and accessories locally and finish the machines to meet the requirement of the foreign customers.

Total financial outlay : Rs. 10 lakhs.

Information, Codification and Documentation in Machine Tools

Establishment of a 'National Information and Documentation Centre'

It is noted that the country does not have a technical press of any large standing and that the technical information services are at best functioning only in name. The functions of the proposed centre will cover broadly the documentation aspects of research and development and new techniques of machine tools on the one hand and production technology on the other.

act as a national clearing house of machine tool and production engineerings and will
retrieve, translate and disseminate world literature on these subjects. The centre will
a service centre for technical information of users including manufacturing industries,
h institutes and university faculties, provide reprographic services to scientists, engineers
hnicians, edit and publish periodicals, hand outs of interest, reports, etc., organise seminars,
and conferences, promote communications among specialists and maintain a register
elopment activities in the country in machine tool and production engineering.

otal financial outlay : Rs. 200 lakhs.

Metal Working & Metal Forming Tools (Including Hand Tools)

shment of a 'Metal Cutting Tools Institute'

oth CMTI and CITD have done considerable work in the development of Metal Cutting
in High Speed Steel and Hard Metal. Although those institutions have made considerable
butions in this field, their main concentration is in the field of machine tools in the case
TI and training of tool designers, craftsmen, etc. in the case of CITD. The Metal Cutting
nstitute, which is proposed to be established at Poona or near IIT, Bombay will concentrate
design, development, research and testing of metal cutting tools. It will also undertake
elop optimum tool applications, provide advisory consultancy services including assistance
ign and development of wood working tools, investigate problems identified by industries
rovide training to metal cutting and wood working tool designers.

otal financial outlay : Rs. 220 lakhs.

lishment of a Metal Forming Tools Institute

CITD, Hyderabad is at present engaged in training tool designers and tool room techni-
in metal cutting tools, jigs, fixtures, gauges, other sophisticated tools and to a limited extent
n metal forming tools. However, in order to meet the current and projected demands,
lerable RDD activity in metal forming tools is needed. This includes RDD activity in
for conventional cold working operations, shearing, bending, deep drawing, coining,
ling etc. Tooling for modern metal forming processes, high rate forming operations like
sive forming, power spinning, spin forging or flow turning operations are almost new fields
need a considerable amount of research effort. It is therefore, necessary to expand the
ties of CITD, Hyderabad, to keep abreast of the latest technological developments in the
of metal forming tools.

Total financial outlay : Rs. 230 lakhs.

lishment of an Abrasives Institute

The largest manufacturing capacity in the country for abrasives exists in the Madras—
alore sector. IIT, Madras has already done considerable work in RDD for abrasives and
such a facility can be started around the existing nucleus. The main functions of the
sives Institute will be to carry out applied research for the development of abrasives, bonding
edures, new processes and proper understanding of the grinding process to fulfil the needs
e engineering industry and evolve new technologies. This will include research in the
of diamonds and the development of diamond tools, and bonded abrasive machining pro-
s such as cylindrical, surface, centreless and profile grinding, honing and super finishing

and high speed grinding. Simultaneously the Institute will investigate problems identifiec the industries and provide a feed back to the machine tool designers. It will also pro training in order to improve the level of industrial knowledge of good grinding practice. estimated financial outlay is Rs. 183 lakhs.

Establishment of a Hand Tools Institute

The hand tool industry is spread out considerably in the small scale sector. In Jul dur only, there are more than 300 small scale units manufacturing hand tools. Out of t 25 units are exporting their products and their approximate export per year is Rs. 70 la These small scale units are facing numerous difficulties in regard to raw materials, pr machinery, jigs and fixtures, design, process technology, know-how, packing, procurement e

Keeping in view the export potential of hand tool industry, the application of mo techniques through organised efforts will very much boost its manufacture and product di sification. The manufacturers of small tools, due to their very small size, are unable to a expensive laboratories for metallurgical tests and to appoint qualified engineers for RDD The Hand Tools Manufacturers Association has conveyed the difficulties they are facing present, which are enumerated as under :—

(a) Lack of technology of blanking/shaping of raw material prior to forging rations.

(b) Lack of facilities for design and manufacture of jigs and fixtures.

(c) Heat treatment of products—hot and cold forming.

Therefore, in order to solve the above problems, the setting up of the RDD facility hand tools is very essential.

Total financial outlay : Rs. 145 lakhs.

Establishment of 'Indian Manufacturing Tool Research Association' (IMTRA) & Exte Centres

Keeping in view the size and largeness of the metal cutting, metal forming and tools industry and its application, a coordinating body, namely IMTRA, should be set up.

Although RDD efforts are being put in at various levels in the country, the fruits of technologies are not available to the end users mainly due to lack of communication an wide distribution of the industry. IMTRA will have branches at various industrial ac centres in the country to establish constant touch with the manufacturers and the users problem identification and try to propose solutions to their problems, preferably on the It will be as such a media for continuous interaction between the manufacturers and educational institutions and research bodies to ensure growth and use of technology for benefit of all. It will fill in the missing link of the long felt absence of coordination, and also have a small documentation centre which will work in close liaison with the centra documentation centre which will be set up at CMTI. This documentation centre will vide specialised service to the industry and its users.

Total financial outlay : Rs. 125 lakhs.

Development of special purpose tools

Due to non-availability of special purpose tools namely Gear Cutters, Thread G ing Wheels, Thread Chasers, Die Heads, Micro Bores, costly equipment having high ma rates, like Gear Cutting Machines, Thread Grinding Machines, Special Purpose Machines, ot used fully, thereby resulting in poor productivity. It may be worth mention- ere that some of the manufacturers of cutting tools claim that they have necessary techni- now-how to meet the sophisticated and specialised requirements, but their claim is not shared by the user industry as these items are not readily available in the market. The facturers have indicated their willingness to develop some of these tools if provided with ial assistance.

Total financial outlay : Rs. 40 lakhs.

Additional Projects

lishment of RDD Centre for Automobile Tyre Industry

The available know-how in the field of conventional tyres is unfortunately highly dis- d within individuals in the country. For an effective transfer capability for a complete try to be set up based on indigenous know-how, there has to be a proper and adequate tional structure which would make a cohesive, coordinated approach extending over e required technological disciplines, different types of elastomers, cords and fabrics in r, rayon, nylon, tyre design, tyre making machinery design, from the beginning of the facturing processes right upto the end of the finished products, fully acceptable to the mers. It is, therefore, necessary that a major RDD effort be mounted forthwith and der to make it most effective it should be industry oriented. The RDD set up will there- have captive links with atleast one major production unit of about one million tyre capa- Such an RDD unit will deal with all aspects of tyres, from basic materials to design, trials etc. It would be necessarily multi-disciplines with chemistry, physics, mechanical eering, electrical and electronic engineering, systems engineering, integrated for the con- us development of better and more economic tyres. It will also provide testing facili- for tyre development which are in themselves very elaborate and expensive. In addi- it will have links with IPCL and other supporting complementary organisations which much to contribute in the development of elastomers, tyre cords and fabrics, adhesives other chemicals required.

Total financial outlay : Rs. 250 lakhs.

rgency funding for development of 50 machine tools as per NCST Plan on Machine s (HMT/CMTI)

Of the 50 tools identified, DPR's for 4 have already been prepared. These four compe- oriented machine tools are : (1) Electro Discharge Machine (2) Front Automatic king Lathe (3) Vertical Machining Centre, Auto tool changer and Precision Index e (4) Numerically controlled Lathe.

The objectives of this plan are as follows:

(i) To develop those types of machines which are presently being imported.

(ii) To develop technological competence to design and manufacture machine tools of the required type.

(iii) To identify machine tool technologies of a sophisticated nature.

(iv) To attain leadership in selected areas

The four machines listed above are competence oriented machines and are of str importance for development of machine tools and technology in the country.

Front Automatic Chucking Lathe can be economically used for batch sizes of 3 above. The machine is equally suitable for large batches. Tractor, automobile, scoote defence factories, find these types of machines ideal for gear blanks and short piece t work, whose L/D ratio is within one.

Machining centre is particularly suitable where high precision machining is coupled low to medium batch production runs. Because of automatic contouring without exp templates, this machine is ideal for machining of aircraft components, where complicated p in three dimensions result in laborious time consuming and expensive machining.

By virtue of their flexibility NC Lathes are economically suitable for small and m batches of repetitive nature. The entire batch of components are turned with the same pu tape. Very costly components can be turned with advantage on NC Lathes.

Total financial outlay : Rs. 160 lakhs.
(for four machine tools).

Note : The total estimated cost of development of 50 machine tools is Rs. 325 lakhs.

SECTOR—HEAVY ENGINEERING

HEAVY ENGINEERING

Heavy Engineering Sector is concerned with the production of plant and equipment for the capital intensive industries. The significance of this sector both from the economic and technological view-points is evident from the past investments made in this sector which total approximately Rs. 3000 crores and from India's continuing imports of over Rs. 400 crores worth of machinery annually.

Till now practically all the capacity built up in this sector has been based on foreign collaboration resulting in procurement of capital items from abroad. In this process of transfer, however, there has been a lack of recognition of the magnitude and pace of technological development necessary for absorption of the underlying technology, despite the fact that adequate number of scientists capable of absorbing the associated technology and making further developments thereon exists within the country. The net effect of this omission is the improper and low utilisation of the rated capacity existing in the country, losses on investments and continued heavy dependence on imports.

Lack of adaptation and conversion of the imported technology, appropriate to Indian conditions, has resulted in continued imports of operational and maintenance requirements in a sector, the principal function of which is to achieve import substitution. If in the 5th Plan foundations are not laid for research, design, development and manufacture of all such capital machinery suited to India's own designs, under-utilisation of installed capacity and import dependence in this key area will persist.

In the previous plan periods a number of heavy engineering industries were set up with reasonably strong design offices attached to them. These design offices functioned mainly for preparation of shop drawings for current production based on imported or purchased designs. They rarely function as advanced design units' developing designs for the projected demands of equipment needed in the country, or of new machinery, or improved versions of the existing machinery or machines larger than those for which drawings were obtained under collaboration. This has resulted in import of machinery of specifications different from the existing machinery to a smaller or larger extent, even though production facilities for manufacture of such machinery exist in the country. Therefore, in this sector highest priority is being assigned for strengthening of design offices, to assess the demands and specifications of machinery and embark on design and development for the projected demands of the 5th and subsequent plans in order to reduce imports drastically.

In heavy engineering, research and development plans are mostly by way of full size prototype developments. These RDD activities are mostly carried out by the design offices of the manufacturing units.

The Heavy Engineering Sector was divided by the NCST into 16 Expert Planning Groups (as given below) for identifying gaps in design & technology, to assess the directions n which RDD efforts are to be launched to obtain optimum dividends and to accelerate the pace towards achievement of self-sufficiency. These expert groups, involving nearly 200 scientists, technologists and administrators drawn from industries and government, prepared the S&T Plan for heavy engineering.

1. Heavy Electric Equipment for Power House, Transmission Sub-Station, Mill Drives, Traction Equipment, Steam & Water Turbines.

2. Heavy Pressure Vessels, Boilers, Heat Exchangers, Dryers etc.
3. Equipment for Fertilizer Plants, Petroleum Refineries and Petro-Chemical Plants, Heavy Duty Pumps, Compressors & Special Pumps for Chemical Industries.
4. Heavy Machine Tools.
5. Steel Plant & Metallurgical Plant Equipment.
6. Mining Machinery, Ore Beneficiation Equipment & Heavy Earth Moving Equipment.
7. Port & Harbour Machinery.
8. Special Requirements of Defence.
9. Cement, Paper & Sugar Machinery.
10. Process Control Instrumentation.
11. Special Machinery for Printing, Packaging, Bottling, etc.
12. Equipment for the manufacture of Fabrics, Felts, Filters etc.
13. Equipment for Wires & Cables, Wire Ropes & Plastics Extrusion.
14. Information Census Survey in Heavy Engineering.
15. Export Promotion Forecasting Potential.
16. Drilling Rigs.

These groups have identified 61 RDD projects for hardware development for execution during the 5th Plan involving a financial outlay of Rs. 109 crores. Additionally 8 RDD projects suggested by the task forces in which NCST was also associated, have been included in the NCST plan involving a financial outlay of Rs. 40.5 crores. The total financial outlay for the entire sector is nearly Rs. 138 crores which excludes approx. Rs. 12 crores required for data bank in Heavy Engineering. This sum is reflected in the National Information System.

The investment in the Heavy Engineering sector is of the order of Rs. 3000 crores. It is estimated that the utilisation factor of this sector has not been more than 30 per cent. The RDD activity on such huge investments has so far been negligible and since new institutes for organised activity have to be set up for the first time, the total financial investment for RDD activity in Heavy Engineering has to be of the order of Rs. 138 crores (this total includes capital and recurring expenditures) without which the present idle capacities of the Rs. 3000 crores investment can never be harnessed. This expenditure on RDD investment should not necessarily be related to the 5th Plan investment alone in the Heavy Engineering Sector since there was little RDD infrastructure on the earlier investments but, on the other hand, to the overall imports of heavy engineering items under the classification of capital goods which in 1970-71 alone in non-electrical machinery, electrical machinery and transport amounted to approximately Rs. 380 crores. If this trend continues in the V Plan the import bill could amount to more than Rs. 2000 crores. Therefore, an investment of Rs. 138 crores in RDD activity in this sector is absolutely essential to catch up with past omissions and save on imports.

The projects identified in this sector are classified into projects for strengthening RDD facilities in public enterprises, RDD projects to be implemented in public sector enterprises and new RDD organisations or facilities. Since the nuclei already exist in some public sector units like HEIL, HEC, HMT etc., for RDD activities, augmentation of these facilities will yield rapid results. The public sector units will take up RDD projects for key industries like steel, paper, printing, cement & cable making. New RDD organisations have been proposed only in areas where there is negligible indigenous expertise or no organized or purposeful activity.

Amongst the new organisations or facilities proposed, it may be pointed that the industan Paper Corporation is envisaging the establishment of an RDD institute in paper in-ustry upto the stage of pulp making and for development of process equipment (to be establish-d with UNDP assistance) and it is suggested that the objectives of this Institute may be widen-d to cover the equipment design and standardisation of paper making machinery. In regard cement machinery, the Government has accepted that the country should attempt to engi-eer 2000 T cement plants in the near future and in this context it is necessary to create faci-ties for design and development of such large plants.

The Planning Commission task forces in which NCST was also associated have re-ommended the establishment of internal combustion engine and automotive RDD institutes nd an aluminium application centre. These programmes are included in NCST Plan.

FCI, BHPV, BHEL, EIL and other public sector organisations have clearly identi-ed the need for setting up of a Heat and Mass Transfer Institute and a Chemical Equipment esign Institute in order to enable these organisations to supply complete fertiliser, chemical nd petro-chemical plants on a turn-key basis. This is important because a considerable mount of non-standard or non-vendor equipment is still being imported for lack of designs ven though the items can be manufactured in the country. Very often the basic data for esign of heat exchangers, used in these industries, is not available for equipment design. The eneration of this data by an appropriate institute will enable the equipment to be designed in he country instead of obtaining this information or the complete equipment design, involving his information, by import.

In the fields of power and telecommunication cables, printing machinery and gra-hic technology, there is absolutely no organized or institutionalised activity, coordinating the equirements of the user ministries or organisations with the potentialities of the manufacturers n the country to achieve self-reliance in these areas. There is no single body to attempt an ntegrated approach to ensure development of capacities for manufacture of tele-communica-ion cables, telephone & switching equipment, auxiliary materials or for design and develop-ment of capital machinery required in these industries. As a result, the imports of capital oods and cables continue. During the 5th Plan period, there is a proposal to set up nearly 15 new factories by Indian Telephone Industries and Hindustan Cables Ltd., (HCL) costing about Rs. 191 crores. In spite of this, the shortfall envisaged in switching equipment, tele-phone instruments, cables, etc. is of the order Rs. 313 crores. The necessity for an inte-grated approach towards solution of this problem by the Ministries of Communications, Elec-tronics, Heavy Industries, Industrial Development, NCST, Defence, and other organisations has been recognised. The establishment of an institute for RDD in Power and telecommunica-tion, cables, wires and equipment, is therefore proposed. The position with regard to printing in-dustry is identical. For the development of capital equipment and the various items of graphic technology, required by the printing industry, another institute is recommended.

The proposed data bank on Heavy Engineering will form a part of the national in-formation services to be organised separately. Therefore, the sum of Rs. 1184 lakhs has not been included in the S&T plan of the Heavy Engineering sector.

Speedy implementation of the RDD projects, identified by the expert groups, will result in self-reliance and freedom from continued dependence on imported technology and products. The S&T plan of this sector envisages employment of 12,000 scientists, engineers and other technical personnel.

It is to be recognised that the Heavy Engineering Sector forms the backbone of the country's economy, for it provides machinery and equipment which then can produce all the required goods like heavy electrical equipment, heavy pressure vessels, boilers, fertilizer plants steel plants, chemical plants, sugar machinery, paper machinery, cable making machinery, etc

A broad picture of the programmes indicated by each planning group is given below :

Heavy Electrical Equipment for Power House, Transmission Sub-station, Mill Drives, Tractio Equipment, Steam & Water Turbines.

Power generation plays a vital role in the economy. The utilisation of capacity of ou industries has been badly affected by shortage of power supply. The group has assessed th requirement of power generating equipment and accessories during the Fifth Plan period an has identified the gaps. With a view to bridge the gaps and to meet the requirements of powe generation equipment indigenously, the expert group has identified 6 RDD projects. The mos important projects in this group are on power & instrumentation transformers, rectifiers & capacitors of higher capacities (upto 400 KV) and some AC & DC machines.

Heavy Pressure Vessels, Boilers, Heat Exchangers, Dryers etc.

Since the country is envisaging rapid increase in power generation, the development o higher capacity boilers to suit 300 MW. 500 MW and later 800 MW turbo-generators is of immediate necessity. In the past, all boilers made in the country were manufactured on th basis of design data supplied by the foreign collaborators. Now that the country has acquire sufficient design competence in this field, it is necessary to build up our own strength in consolidating the information already available and to acquire and develop further know-how. Th establishment of a National Boiler Institute has therefore been recommended by the exper group for taking up RDD activities in boiler technology. The proposed institute will als take up the task of standardization of boilers.

Equipment for Fertiliser Plants, Petroleum Refineries & Petro-Chemical Plants, Heavy Dut Pumps, Compressors & Special Pumps for Chemical Industries.

Fertilizer production has not been in tune with the requirements and of late the shortag has been acute. Similarly, with regard to production of petrochemicals, the targets have no been met. Refining capacity has also been adversely affected in the past. One of the majo gaps has been in capital equipment for these plants. Complete plants were imported repeatedl in the past without any regard to indigenous development. Wide gaps exist in design an fabrication know-how for static equipment.

With a view to bridge the gaps in design & technology the following Institutes have been recommended to be established:

(1) Combined Research Institute for Heat & Mass Transfer.

(2) Research, Design & Development Institute for Chemical Equipment.

Heavy Machine Tools.

There is only one unit in the country manufacturing heavy machine tools. The level o RDD is very low. Therefore, the expert group has suggested the setting up of an RDD unit i heavy machine tools.

Steel Plant & Metallurgical Plant Equipment.

In the field of equipment required for metallurgical plants a lot of effort has to be put in This is very important as we have been importing a huge amount of equipment required. I production of steel is to match with the targets, it will also be necessary to have several plants commissioned in the subsequent plans. Therefore, the need to build up indigen- know-how is essential.

7 RDD Projects have been identified. The most important of these are : establishment an Equipment Design Organisation for Steel Plants, RDD Centre for Aluminium Industry establishment of a Central Mine Design & Construction Cell for mining of non-ferrous als.

ing, Ore Beneficiation and Heavy Earth Moving Equipment

The expert group has identified gaps and have recommended measures and projects to lge these gaps. The establishment of a Central Mining Equipment Design Cell, setting up of ign & Consultancy Cell for beneficiation of coal and coal washeries are the major projects.

t and Harbour Machinery

The facilities for supplying port and harbour machinery and bulk handling equipment st in Mining & Allied Machinery Corporation but they need to be strengthened in order to et the present and future requirements of such machinery in the country. The expert group therefore recommended the setting up of groups for the development of plant engineering orts), design of bulk handling equipment, design of container cranes and other equipment.

cial Requirements of Defence

(Projects included in the Panel on Machine Tools)

ment, Paper & Sugar Machinery

The difficulties faced at present in these fields are mainly due to lack of RDD. Unless are able to build up indigenous capabilities we will be forced to resort to foreign collabora- n repeatedly. In order to be self-reliant in this field, it is necessary to start intense RDD tivities.

The expert group has strongly recommended that intense RDD should be undertaken to dge technological gaps and to attain self-sufficiency, especially with regard to paper & cement. r accelerated development of indigenous skills in RDD for cement, paper and sugar industry, e RDD efforts and the amounts required have been identified and included under additional ojects.

ocess Control Instrumentation

The estimated instrumentation requirements during the V Plan are about Rs. 110 crores. ne import content is about 25 per cent of the above sum. The expert group has identified the ps and has recommended measures to reduce the high import content so that the country can self-reliant to a greater extent.

The total financial outlay is estimated to be Rs. 550 lakhs. Out of this Rs. 270 lakhs ll be raised from industry while the balance of Rs. 280 lakhs should be met by Government nder the S & T Plan.

ecial Machinery for Printing Packaging, Bottling, etc.

There is absolutely no coordinated activity for development of printing machinery. The xpert group, after studying in depth the problems of the sub-sector, has identified the gaps and as suggested short and long term measures to bridge the gaps. The group has identified 23 evelopmental projects. Besides, the establishment of a Printing Machinery and Graphic

Technology, Research, Design and Development Institute has been stressed. The institute very essential for building up expertise in printing technology and design of machinery.

Equipment for the manufacture of Fabrics, Felts, Filters, etc.

The expert group has strongly recommended the setting up of strong engineering divisi in the textile laboratories. These divisions will take up intense RDD in textile machinery whi needs modernisation and also develop new and modified machinery. A total outlay Rs. 486 lakhs is estimated, out of which Rs. 243 lakhs has been recommended to raised by industry during the 5th Plan by 1 per cent cess on turn over. The expert group h suggested that a matching grant of Rs. 243 lakhs should be provided by the Government un the S & T Plan.

Equipment for Wires & Cables, Wire Ropes & Plastics Extrusion

The equipment, for the manufacture of wires & cables, is at present imported to a lar extent. With rapid industrialisation and urbanisation, the demand for wires and cables expected to rise manifold. Unless we are able to do RDD indigenously, it will be necessary continue import of equipment. The expert group has suggested measures to bridge the ga The establishment of a Telecommunication and Power Cables Wires & Equipment Research, Desi and Development Institute has been strongly recommended by the expert group. This Institu will create indigenous expertise in the manufacture of capital equipment and process technolo

Information Census Survey in Heavy Engineering

At the moment, there is a wide gap in the country in dissemination of technical informati particularly in the field of Heavy Engineering. Technologies in the field of Heavy Engineeri have been, by and large, imported from various countries, and though there exists some cons lidation of data with the individual units, particularly in their respective design organisatio no attempt has been made at the national level to collect, collate and catalogue the vast amou of information being generated in this field. Therefore, the expert group has recommend the setting up of a 'Data Bank in Heavy Engineering' for complete inventory of available tec nologies and designs.

Export Promotion Forecasting Potential

This expert group has identified that some of the capital machinery manufactured in genously can be exported against international competition. In order to explore the possibil of greater exports it will be necessary to collect information on the performance of machine already supplied. Market surveys will also have to be conducted.

Oil & Water Drilling Rigs

The expert group has identified the gaps in technology & design and after assessing t demand in the 5th Plan period, has suggested measures to bridge the gaps. The development water drilling rigs, tools and accessories is very important to give a boost to agriculture in ar zones.

There is also need to develop oil drilling rigs for drilling to depths of 6 km. to 9 k Intense RDD efforts are required to develop new rigs for these applications.

Additional Projects

The projects identified are in the fields of cement, machinery, paper machinery, die engines, transport vehicles, etc. Presently the RDD efforts in these areas are very meagr therefore, RDD efforts are very essential.

The financial outlays recommended by the various Planning groups are given below:—

No.	Planning Group	Financial Outlay (Rs. lakhs)
1.	2	3
1.	Heavy Electric Equipment for Power House, Transmission Sub-Station, Mill Drives, Traction Equipment, Steam & Water Turbines.	3245.00
2.	Heavy Pressure Vessels, Boilers, Heat Exchangers, Dryers etc.	275.00
3.	Equipment for Fertilizer Plants, Petroleum Refineries & Petro-Chemical Plants and Heavy Duty Pumps, Compressors & Special Pumps for Chemical Industries.	708.00
4.	Heavy Machine Tools	317.79
5.	Steel Plant & Metallurgical Plant Equipment	2007.00
6.	Mining Machinery, Ore Beneficiation Equipment & Heavy Earth Moving Equipment .	78.39
7.	Port and Harbour Machinery	45.00
8.	Special Requirements of Defence (Included in Panel on Machine Tools) . .	
9.	Cement, Paper and Sugar Machinery (Included in Additional Projects). . . .	
10.	Process Control Instrumentation	280.00
11.	Special Machinery Printing, Packaging, Bottling etc.	590 00
12.	Equipment for the manufacture of Fabrics, Felts, Filters etc.	243.00
13.	Equipment for Wires & Cables, Wire Ropes & Plastics Extrusion	1581.75
14.	Information Census Survey in Heavy Engineering	1184.00*
15.	Export Promotion Forecasting Potential	25.00
16.	Drilling Rigs	100.00
17.	Additional Projects	4050.00
18.	States	250.00
	GRAND TOTAL	13795.93

*Not included in the total for Sector. Transferred to National Information Systems.

The projects identified by the various Planning Groups are as follows :—

Project Index No.	Title of the Project	Financia Outla (Rs. lakhs)
1	2	3
	G1 — Heavy Electric Equipment for Power House, Transmission Sub-Station, Mill Drives, Traction Equipment, Steam and Water Turbines	
$S_4G_1P_1$	Constitution of Research Groups & Teams (Hydrosets)	1100.00
2	Constitution of Design & Development Groups & Teams (AC & DC machines) . .	700.00
3	Development work relating to Power & Instrumentation Transformers, Rectifiers & Capacitors.	900.00
4	Manufacture, Research & Development of Circuit Breakers, Isolators & Lightning Arrestors.	525.00
5	Development work relating to Hydro-Dynamic Equipment including Pumps & Turbines .	20.00
6	Systems & Application Engineering for Industrial Projects (Included in G_4P_8).	
	Total G_1 .	3245.00
	G_2—Heavy Pressure Vessels,Boilers, Heat Exchangers, Dryers etc.	
$S^4G_2P_1$	National Boiler Institute, Trichy	275.00
	TOTAL G_2 .	275.00
	G3 –Equipment for Fertilizer Plants, Petroleum Refineries & Petro-Chemical Plants. Heavy Duty Pumps, Compressors and Special Pumps for Chemical Industries	
$S_4G_3P_1$	Combined Research Institute for Heat and Mass Transfer	400.00
2	Research, Design and Development Institute for Chemical Equipment	308.00
	TOTAL G_3	708.00
	G4—Heavy Machine Tools	
$S_4G_4P_1$	RDD Centre for Heavy Machine Tools	317.79
	. . . . . . TOTAL G_4	317.79
	G5—Steel Plant & Metallurgical Plant Equipment	
$S_4G_5P_1$	Equipment Design Organisation for Steel Plants	727.00
2	RDD Centre for Aluminium Industry	350.00
3	Equipment Design Organisation for Aluminium Plants	190.00
4	Central Mine Design & Construction Cell for mining of Non-ferrous Metals covering copper zinc, lead and nickel.	230.00
5	Non-ferrous Research Centre (Included in Panel on Mining steel and Mettallurgical Industry)	
6	Evaluation and Performance Tests on various types of present and future combustion systems (Furnaces)	10.00
7	Control Systems Design Organisation	500.00
	TOTAL G_5 .	2007.00

1	2	3
	G_6—Mining Machinery Ore Beneficiation Equipment and Heavy Earth Moving Equipment	
G_6P_1	Central Mining Equipment Design Cell	60.00
2	Designs and Consultancy cell for beneficiation of coal & coal washeries	
3	Development of double drum ranging arm shearer	6.35
4	Development of long wall coal cutting machine with curved jib	3.20
5	Development of flame-proof diesel locomotive	2.79
6	Development of shuttle car	4.25
7	Development of low-pressure axial flow main mine fan	1.80
	Total G_6	78.39
	G_7—Port and Harbour Machinery	
$1G_7P_1$	Establishment of development cells in plant engineering (ports) for the development of port and bulk handling equipment	45.00
	Total G_7	45.00
	G_8—Special requirements of Defence	
	INCLUDED IN THE PANEL ON MACHINE TOOLS	
	G_9—Cement, Paper & Sugar Machinery.	
	*1. Development of a 2000 T and 100-150T cement plant during the Fifth Five Year Plan.	
	*2. Establishment of facilities for project engineering of paper mills for production of newsprint and RDD facilities for standardisation and modification of paper making machinery.	
	G_{10}—Process Control Instrumentation	
$G_{10}P_1$	Funding of RDD at manufacturing organisations	280.00**
2	Funding of RDD at national laboratories	
3	Establishment of National Instrumentation coordinating & Information Disseminating Agency	
	TOTAL G_{10}	280.00
	G_{11}—Special Machinery Printing, Packing, Bottling etc.	
$G_{11}P_1$	Printing Machinery & Graphic Technology Research Design & Development institute	250.00
2	Design & production of matrices for Indian languages compositions	25.00
3	Development of typewriter key-boards & computing units	10.00
4	Development of photo-setting units	20.00
5	Development of plate-making machinery	5.00
6	Development of the dark room type of camera & process enlarger	6.00
7	Development of the Dark film processing equipment	1.00
8	Development of colour scanners	15.00
9	Development of powderless etching machine	5.00
10	Development of litho printing down frames & litho plate coating machines	1.00
11	Development of automatic Platen Machine RA3 size	5.00
12	Development of Letter Press Proof Press	2.00
13	Development of single colour sheet fed machine RA3 and RA4 size	10.00
14	Development of Offset Proof Press	5.00
15	Development of folding machine	3.00
16	Development of perfect binding machines	3.00

(*) Additional projects which have not been identified by the working group. The financial outlay not indicated here but is included in the additional projects.

(**) Out of Rs.550 lakhs proposed to be spent on RDD, industry will raise Rs.270 lakhs. The balance of Rs.280 lakhs will have to be met by Govt.

1	2	3
17	Development of case making machinery	3.00
18	Development of gathering machines	5.00
19	Development of wire stitching machine	2.00
20	Development of envelope making machine	10.00
21	Development of rotary cutting and creasing machines	4.00
22	Development of photo-sensitive materials for graphic arts	25.00
23	Development of following items: Development of mounting bases, blocks, locking devices, plate registering devices, electronic sheet counting equipment, measuring and testing devices, anodisation of printing plates, polymer plates, photopolymer plates, presensitized plates, paper masters, light sources including Xenon lamps.	50.00
24	Development of packaging machinery	125.00
	TOTAL G_{11}	590.00
	G_{12}—Equipment for the manufacture of Fabrics, Felts, Filters etc.	
$S_4G_{12}P_1$	Setting up engineering divisions in the textile laboratories for RDD activities	243.00*
	TOTAL G_{12}	243.00
	G_{13}—Equipment for Wires & Cables, Wire Ropes & Plastics Extrusion	
$S_4G_{13}P_1$	Telecommunication and Power Cables and equipment RDD institute	1004.18
2	Development of extruders	49.05
3	Development of 4 machines** by CMERI, Durgapur	16.12
4	Augmentation of RDD at TRC	66.40
5	Funds to manufacturers for RDD	446.00
	TOTAL G_{13}	1581.75
	G_{14}—Information Census Survey in Heavy Engineering	
$S_4G_{14}P_1$	Establishment of Data Bank in Heavy Engineering	1184.00***
	TOTAL G_{14}	1184.00
	G_{15}—Export Promotion Forecasting Potential	
$S_4G_{15}P_1$	Data Centre for International Market Intelligence and related information	25.00
	TOTAL G_{15}	25.00
	G_{16}—Drilling Rigs	
$S_4G_{16}P_1$	RDD in Oil & Water Drilling Rings	100.00
	TOTAL G_{16}	100.00

(*) Out of Rs. 486 lakhs proposed to be spent on RDD Rs. 243 lakhs will be raised from industry by 1% cess on turn over. The balance of Rs. 243 lakhs should be met by Govt.

(**) The 4 machines to be developed are:—
- (i) High Speed Paper Insulating Machine.
- (ii) High Speed Twinning Machine for Paper and Plastic Insulator Cables.
- (iii) Trunk Cable Insulating Machine.
- (iv) Trunk Cable Quadding Machine.

(***) Not included in the grand total for the sector. Projects transfered to National Information systems.

Additional Projects

1	2	3
1.	15 MW turbo-generator for fast breeder test reactor being developed by Reactor Research Centre, Kalpakkam, Madras.	350.00
2.	Pump Design & Development Institute	50.00
3.	Establishment of Aluminium Application Centre	200.00
4.	Development of Oil Drilling Rigs	20.00
5.	6000T Press Forgings	100.00
6.	Central Institute for Paper and Pulp development including facilities for project engineering of paper mills and for standarzation and modification of paper making machinery.	160.00
7.	RDD in Cement Machinery	2140.00
8.	RDD in Automotive Ancilliaries, Diesel Engine & Transport Vehicles	1030.00
	TOTAL	4050.00

OUTLINE OF THE PROJECTS

Hydro-Generating Sets-Research, Design and Development Groups for equipment, viz. Hydro-turbines, Generators and Controls including work on Reversible Pump Turbines, Electrical Machines and Controls.

These RDD Projects aim at the development of computerised analysis of complex turbine and generator parameters with reference to voltage wave forms, fundamental constants, behaviour of windings under various operating conditions, and stress analysis of generator structural parts. In addition, the development of improved thrust bearings, static excitation systems, auxiliaries and components, like electro-magnetic valves, pressure-relays, signalling devices and bypass valves, etc. for hydro stations is also included. The development of materials, like magnetic steel, high tensile steel and certain nickel bronze steels is proposed to be taken up. The nucleus for doing the above work exists in the plants of BHEL/HEIL.

Total financial outlay : Rs. 1100 lakhs.

AC and DC Machines, Including Design and Development of Special Motors and Insulation Systems for Electrical Machines

The development of high-speed boiler feed pump motors, synchronous induction motors for very low speeds, brushless synchronous motors, high speed commutator machines and solid state controls are included in this project. In addition, the development of certain basic forgings and castings, particularly for AC and DC machines would be taken up. Finalisation of insulation systems for large machines is also envisaged, as a part of 'Materials Development Programme'.

Total financial outlay : Rs. 700 lakhs.

Power and Instrumentation Transformers, Capacitors and Rectifiers.

The project envisages the development of special designs and construction techniques for transformers for site assembly and testing and basic development of technology for 400 KV transformers. The development of materials, particularly electrical steels, insulating paper and aluminium foils as well as the substitution of copper by aluminium for low-rating transformers is also proposed to be taken up for investigation.

The nucleus already exists for this work at BHEL/HEIL.

Total financial outlay : Rs. 900 lakhs.

Circuit Breakers, Isolators and Lightning Arrestors.

This RDD project includes the development work connected with 400 KV circuit breaker etc. Aim is to bridge the gaps existing in designs and bring them upto international standards Work would be carried out on vacuum interruptors, gas-blast circuit breakers, minimum oi circuitbreakers and high-voltage DS breakers also. In addition, advance design for HV isolators is also to be taken up.

The nucleus already exists for further work at HEIL/BHEL.

Total financial outlay : Rs. 500 lakhs.

Development of Hydro-dynamic Equipment including Pumps and Turbines.

At present BHEL, Hardwar and HEIL, Bhopal have in their possession complete desig expertise for the design and manufacture of Francis and Kalpan turbines, electro-hydraulic governors, oil pressure units, automation equipment and auxiliary equipment such as spherical or disc valves. However, expertise has to be developed in the following and for this purpose, investigations have to be undertaken.

The design and technology of manufacture of bulb or capsule type hydrosets, reversible pump turbine hydrosets and diagonal flow type turbines need to be developed. Expertise is also required to be developed for running hydro-sets in synchronous condensor regimes and for design of water by-pass arrangement, either through the turbine relief valve with the help of stabilizer or otherwise.

These fields require development work on a prototype design. The total financial outlay is Rs. 20 lakhs. (This excludes the costs of prototypes which can be charged to actual orders.)

National Boiler Institute, Truchi.

The Institute will be engaged in the development of :

1. Large capacity boilers.
2. Once through boilers.
3. Waste heat boilers for refineries and fertilizer plants.
4. Recovery boilers for paper and pulp industry, municipal incinerators, fluid bed combustion systems, MHD programme, nuclear power stations, steam generators etc. Burners, and all boiler house auxiliaries like soot blowers, fans, dust collectors etc. would also be developed.

Total financial outlay : Rs. 275 lakhs.

Combined Research Institute for Heat and Mass Transfer.

The purpose of research in Heat Transfer is to carry out investigations for developing data and design information on industrial scale units covering such items as the following :

1. Heat Transfer with phase change for multicomponent mixtures.
2. Fouling factors.
3. Finned tube exchangers.

4. Heat exchangers for nuclear applications.
5. Spirally wound and plate-type exchangers for high pressure and cryogenic services.
6. Estimation of physical properties.
7. Radiative heat transfer.
8. Burners.

The purpose of research in Mass Transfer is to study performance characteristics of large le units involving items like the following :

1. Valve trays—hydrodynamics.
2. Packed columns.
3. Tray efficiency.
4. Mechanically-aided liquid extractors.
5. Extractive distillation systems.
6. Equipment for vacuum services.

Total financial outlay : Rs. 400 lakhs.

esearch, Design and Development Institute for Chemical Equipment.

The purpose of the proposed Institute is to develop design and build prototypes of chemi-l equipment such as:

1. Vacuum filters.
2. Centrifuges.
3. Scraped surface heat exchangers.
4. Special pumps, Compressors etc.
5. Evaporators.
6. Dryers etc.

Total Financial outlay : Rs. 308 lakhs.

esearch, Design and Development Centre for Heavy Machine Tools.

The heavy machine tool industry in India is of relatively recent origin. There is little velopment activity in this field, and as a result there is an overall technological gap in RDD r heavy machine tools.

The expert group feels that the most suitable and effective body to undertake RDD would a full fledged design department within the overall organisational set up of Heavy Machine ools Plant (HMTP) in Heavy Engineering Corporation (HEC).

Considerable development has taken place in the last twenty years, and it would be desir-le to update the design of some of the machine tools presently being manufactured.

The HMTP Design and Development Centre will, therefore, have a two fold task for development, firstly, to upgrade its present range of manufacture, and next to develop prototypes for an additional range of machine tools.

To this end, separate facilities for advance design and development of prototypes of new machines will have to be established. The Bureau of Public Enterprises (BPE) has also recommended the establishment of advance design cells at manufacturing units.

Estimated financial outlay : Rs. 317.79 lakhs.

Equipment Design Organisation for Steel Plants.

At present there exist agencies for design and development for fertilizer plants, petrochemicals plants and several others. But in the field of heavy engineering several gaps exist in detailed engineering and equipment design. CEDB of HSL can take up project designs, but for product (equipment) design there as several gaps, particularly in the following areas:

(a) Pelletising plant.

(b) Coke ovens above 6 meters.

(c) Blast furnaces above 2000 m^3.

(d) L D convertors above 200 T.

(e) Continuous casting machines for slabs and blooms.

(f) Special purpose rolling mills.

(g) Sponge iron plant.

(h) Sintering plant (above 312 m^2).

Steel plant equipment design and manufacture are relatively new fields for which Heavy Engineering Corporation's design office has been established.

There are a few design offices in the private manufacturing organisations also, but these design offices have been primarily utilised for adapting and modifying the designs, obtained from abroad to suit the indigenous manufacturing conditions. Innovative design has always been relegated to the second position and dependence on foreign countries for setting up steel plants has contributed to such a position.

In the field of equipment design there are very large gaps both in capability and in capacity. The result is that, the foreign exchange component for the existing steel plants is of the order of 44.9 per cent of the total expenditure.

The only way, to reduce the foreign exchange content is, obviously, to augment the production of indigenous equipment required in a steel plant.

The total requirement of steel plant equipment required during the 5th Plan has been assessed as 7,90,000 tonnes. In addition about 5,92,000 tonnes of technological and building structures are also required for the 5th Plan steel programme.

Considering the possibility of more modern equipment being used in the new steel plants and in the expansion of the other steel plants, the equipment may be repeated from earlier available and standard designs. Therefore, designs for about 395,000 tonnes of equipment will have to be developed for the 5th Plan requirements. Assuming a design lead time of two years, the above design work has to be started immediately, so that the same can be completed

1967-77. In view of the fact, that the project design work for the new steel ants, is not yet complete, a total of 4 years time may be available for equipment design work r the 5th Plan targets. This leads to the requirement of preparation of design drawings, for bout 98750 tonnes of equipment annually, which will mean strengthening of existing equipent design cells. This design office will not only produce shop drawings for manufacture in EC, but will also take responsibility for making drawings for equipment manufacture in her industries which are at present unable to manufacture comparatively lighter metallurgical uipment for want of designs, resulting in import of such minor items of equipment also.

The proposed Equipment Design Organisation of HMBP, HEC will take up the following nportant projects forthwith:

(i) 48″ and 54″ hydroset primary gyratory crushers.
(ii) Secondary and tertiary cone crushers 2200 mm (7″—0″).
(iii) Equipment for the 8th coke oven battery for Bhilai Steel Plant.
(iv) Hot and cold sinter screens for Bokaro Steel Ltd.
(v) Equipment for Bhilai convertor shop including wide gauge rolling stock.
(vi) Ladles for vacuum degassing plant.
(vii) 400 tonnes ladles crane.
(viii) Plate mill equipment for Bhilai Steel Plant.

Total financial outlay : Rs. 727 lakhs.

esearch Design and Development Unit for Aluminium Industry.

A Research, Design, Design and Development Unit should be set up for Aluminium Industry overing the field of Science, Technology, Ecology, Economics and Statistics. The existing uminium producers in the country have laboratories for solving their operational, control and evelopmental problems. They also have developed capabilities to put in new plants on a repetive basis. It is, however, felt that additional cooperative and intensive efforts in developg process and allied technology is required.

With the establishment of such an RDD Centre, it will be possible to draw on, the expeence gained and know-how acquired by all producers. Pooling of information on raw mateals, production technology, fabrication and application will provide a medium for better use expertise. This Institute will interact with the Industry on a commercial basis. Each proucer will pay for the project sponsored by him and the product of such projects will become e joint property of the sponsor and the Institute. Other parties may buy these results from e Institute after payment of requisite fees. If any major development takes place in the stitute in the field of technology, this may be sold to the interested parties, both within and tside the country, on payment of fees and royalties, in the same manner as foreign technology commercially available.

The areas of Research, Design and Development covered by the Institute would be on :

(i) Raw materials
(ii) Alumina
(iii) Smelting
(iv) Fabrication
(v) Application
(vi) Documentation

These activities may be supported by requisite laboratory facilities, library and statistician Initially this institute may draw on other national institutes before developing its own facilities The nucleus for such work already exists in Bharat Aluminium Company (BALCO).

Total financial outlay : Rs. 350 lakhs.

Equipment Design Organisation For Aluminium Plants

The purpose of this organisation is to design equipment required for aluminium indust This includes vessels, crushing and grinding equipment, separation equipment, cranes, pot roo equipment, rolling mills and extrusion presses. The requirement of such equipment is assess at 1,04,500 tonnes during the 5th Plan.

Since metal fabrication and rolling mills are akin to those in steel industry, HEC w gather further experience on equipment design, since they already have expertise in design a manufacture of electrolyzers, rolling mills and presses. This recommendation has also be endorsed by BALCO, which will take up project designs and desires HEC to take up produ designs.

Total financial outlay : Rs. 190 lakhs.

Evaluation and Performance Test on Various Types of Present Future Combustion Syste (Furnaces)

Until now combustion systems, particularly gas burners, for primary furnaces, have be entirely imported. The recent trend, due to shortage of coke oven gas in all the existing ste plants, has been to use dual fuel burners, using supplementary oil, in addition to coke ove gas.

It is recommended that hereafter all combustion equipment for primary furnaces shou be standardised as dual fuel type. It is further recommended that, for such burners and sophi ticated combustion systems, indigenous capacity should be created, to reduce the foreign exchan expenditure by way of spare parts importation.

Therefore, the facilities at Central Mechanical Engineering Research Institute (CMERI should be mobilised to the fullest extent to carry out evaluation and performance tests o various types of present and future combustion systems. The facilities at CMERI if require may be augmented, in terms of personnel and testing equipment, to the extent required.

Total financial outlay : Rs. 10 lakhs.

Control Systems Design Organisation

The Heavy Electrical Industry is reported to have a vast amount of basic know-how the design and manufacture of electrical equipment needed for industries and power station but there is a noticeable gap in the know-how for working out project designs and syste designs in electrical equipment, needed for metallurgical, cement, paper and other industrie The know-how for the electrical project designs & detailed engineering is yet to be acquire and developed, and particularly, taking into account the modern concepts including the larg scale application of thyristorised drives. This design unit is required to be established immediatel This recommendation has been made by the expert groups on Heavy Electric Equipment a Steel Plant & Metallurgical Plan Equipment.

Total financial outlay: Rs. 500 lakhs.

Non-Ferrous Research Centre

Since all further development of non-ferrous industrial activity other than aluminium will under public sector, it is considered necessary that a non-ferrous research, Design development unit be established to undertake all investigations for bench scale and pilot it scale testing to establish the design criteria for setting up various processing units. The facilities to be provided under this centre are as follows :

(i) Ore beneficiation pilot plant—50 tonnes per day capacity.

(ii) A combination of pyro/hydro/electro metallurgical pilot plant.

(iii) Additional laboratory equipment.

For a coordinated development of process technology and filling the various technological s in non-ferrous metal industry, it is necessary to give additional facilities to HCL. This provide a link between bench scale testing and commercial scale plants, by installing the essary metallurgical testing facilities on pilot plant scale.

The centre should undertaken the necessary metallurgical testing, evolve process designs collect the necessary design criteria for establishing the feasibility and economic viability of cesses.

The NCST Panel on Mining, Steel and Metallurgical Industry has also identified a prjoect for ing up of facilities for hydro-metallurgy and electro-metallurgy. In order to avoid duplica- this project is included under that panel (Project index No. $S_7G_5P_2$).

Total financial outlay : Rs. 250 lakhs.

ıtral Mine Design & Construction Cell for Mining of non-ferrous Metals Covering Copper, Zinc, Lead and Nickel

There is a considerable gap in the entire field of various activities in copper. There is appreciable gap in project and process designs, for zinc and lead also. Most of the know- in these areas has been obtained from abroad. The purpose of the cell is to develop the essary expertise in Mine Design Engineering and Construction aspects. The unit will also e facilities for training of personnel required to meet the future needs. The unit will take work from feasibility studies to make available the necessary design engineering and cost luation studies necessary for the exploitation of mines on commercial scale. Hindustan pper Limited (HCL) will be in charge of copper, whereas zinc, lead and nickel will be rdinated with Hindustan Zinc Limited (HZL).

Total financial out lay : Rs. 230 lakhs.

ablishment of (a) Central Mining Equipment Design Cell, (b) Design and Consultancy Cell for Beneficiation of Coal and Coal Washeries

(a) At present the Central Mininig Research Station, Dhanbad, is the only organisation ducting research work on mining problems. However, their role is at present limited to ing problems faced by the coal mines in the field of stowing, ventilation, explosives etc. only a small part of their RDD activities is directed towards the mining equipment. There- , it is imperative to set up a Cetral Mining Equipment Design cell, in order to bridge the gap ting in design of mining equipment.

(b) As our coal washeries have been set up with imported know-how, it is necessa to have a cell for design and engineering of complete coal washeries. There is no organisati in the country at present engaged in providing consultancy, design and development servic to the equipment manufacturers. A Design and Consultancy Organisation for beneficiation coal washeries must therefore be established.

Total financial outlay : Rs. 60 lakhs.

Development of Double Drum Ranging Arm Shearer

The Double Drum Shearer is intended for mechanised extraction of coal in longwall fac in conjunction with Snaking Armoured Chain Conveyers.

Total financial outlay : Rs. 6.35 lakhs.

Development of Longwall Coal Cutting Machine with Curved JIB

The curved jib flame-proof coal cutter is meant for undercutting Kerf at floor level, f flight loading of coal and removal of floor coal in longwall coal faces. This can be mount on floor or over armoured chain conveyers.

Total financial outlay : Rs. 3.20 lakhs.

Development of Law-Pressure Axial-Flow Main Mine Fan

The shuttle car is intended for transporting coal/ore from the mine face of galleri to the conveyers, wagons or bunkers in the main roads. The advantages are quick, trackle transportation with high productivity.

Total financial outlay : Rs. 4.25 lakhs.

Development of Law-Pressure Axial-Flow Main Mine Fan

The Axial-flow Main Mine Fan is intended for ventilation of small and medium coal a metal mines. The adjustable blade fan will meet the increased requirement of mine ventilati during development of mines.

Total financial outlay : Rs. 1.80 lakhs.

Establishment of Development Cells in Plant Engineering (Ports) for the Development of P and Bulk Handling Equipment

The facilities for supplying port machinery and bulk handling systems, already in existenc need to be strengthened to enable MAMC to supply the requirements of this machinery in t country.

Total financial outlay : Rs. 45 lakhs.

Cement, Paper and Sugar Machinery

The difficulties faced at present in these industries are mainly due to lack of RDD. Unle we build up indigenous capability, we will be forced to resort to foreign collaboration repeated The export group has, therefore, strongly recommended that intense RDD activities should undertaken in order to bridge the technological gaps and attain self sufficiency especially w regard to paper and cement.

Cement Machinery

Although the country is now making most of the machinery that go as constituent units into complete cement plant, most of the manufacturers in the country are dependent on foreign know-how. For example the know-how for process parameters and design have not been assimilated by the cement machinery manufacturers. In view of this, it is suggested that individual cement machinery manufacturers should set up suitable RDD sections to enable them to develop expertise for bridging technological gaps. For this it is recommended that machinery that manufactures should set apart 2 per cent to 3 per cent of total sales on RDD. Besides, the facilities available in the Cement Research Institute of India and the National Physical & Chemical Laboratories should be utilised for testing raw materials.

Paper Machinery

The industry is of recent origin and due to lack of adequate opportunities for manufacture and supply of paper plants arising out of reluctance of the paper industry in placing orders, the paper machinery industry has not made much progress towards self reliance. This has resulted in import of complete plants with drain of valuable foreign exchange.

There are tremendous gaps in the spheres of project engineering and design know-how. The expert group has suggested that the individual manufacturers should take advantage of their collaboration agreements and start training their people in project engineering and design work. Besides the machinery manufacturers should set aside 2% of their turnover on RDD activities.

Sugar Machinery

This is one of the industries which have been well established in the country from the point of view of import substitution as well as bridging technological gaps. But some of the equipment is still imported. These have to be developed indigenously. The group has suggested that the National Sugar Institute, Kanpur, will be the appropriate agency for these RDD activities. It is further suggested that a 2% investment on turn over should be set apart for RDD by machinery manufacturers.

Cement Machinery

Funding of RDD at manufacturing organisations, funding of RDD at National Laboratories and Establishment of a National Instrumentation Coordinating & Information Disseminating Agency.

Instrumentation Limited, Kota and ECIL have the nuclei of RDD units in their own organisations. The unit at IL will have to cater for tasks connected with systems engineering, simulation and synthesis, as well as human and presentational aspects of control panels and materials The building for the above activity is already under construction at Kota. This Centre will provide instrumentation on a turnkey basis and attain maximum self-reliance, by production of complete items which are presently being imported, by continuous updating of product range and by engaging in forward looking technological investigations on applications such as fluidics etc. Out of an important bill at an average of Rs. 5.14 crores per annum, the control valves and allied items will account for Rs. 27.5 crores during the 5th Plan. The immediate programme of development as Instrumentation Limited (IL) and Electronics Corporation of India Limited (ECIL) includes the development of control valves, hydraulic, pneumatic and electrical actuators, positioners, intrinsically safe circuitry and equipment, electropneumatic and pneumo-electric convertors solenoid valves etc. A detailed programme for the development of these items has already been drawn up.

Further, for implementation of various programmes and for the maintenance of an effective communication grid and liaison between manufacturers, users, academic institutions and the NCST, the Instrumentation Ltd., proposes to set up a National Instrumentation Coordination and Information Disseminating Agency (NICIDA).

For the implementation of the programmes identified by IL/ECIL/CSIO, there will be a considerable amount of basic design and development work to be undertaken in the CSIO, the national laboratories and various research centres in the country. The formulation of the problems associated with the development of instruments and farming out the research projects will be undertaken in totality and monitored by the Instrumentation Limited. The funds required for this purpose for a 5 year period are Rs. 1.1 crores.

The total financial outlay for RDD in the Instrumentation Limited is Rs. 5.5 crores. Out of this Instrumentation Ltd. will be able to find Rs. 2.7 crores from self-generated funds. Therefore, a shortfall of Rs. 2.8 crores has been proposed for funding under the S & T Plan.

Printing Machinery & Graphic Technology Research Design and Development Institute

In order to ensure that the printing industry in India is brought on par with the printing industry elsewhere, the industry has not only to be given modern machinery and equipment but also it must be ensured that current processes and current technological trends are brought into use. There is no coordinated activity for development of printing machinery in the country at all and the few private sector manufacturers are manufacturing outdated machinery and at random without due regard for the needs of the country or for standardisation of equipment. In industries like machine tools there has been a concentrated effort to develop design competence for mastering the duplication of products of collaboration.

As stated above, no design capacity whatsoever exists in the country today to develop new designs. The only way to develop design competence is through the establishment of a Central Institute on lines similar to CMTI. The purpose of this Institute will be not only to design machinery but also to build prototypes and prove them before releasing these designs for actual production to suitable industries, either in the large or medium scale. This Institute will also have a testing and inspection centre for giving comprehensive services, not only on machinery but also on all allied materials and processes associated with printing. The total financial outlay is Rs. 250 lakhs.

Design & Production of Matrices for Indian Languages Composition

There is a great deal of work to be done on design and production of matrices for Indian languages composition. Import of matrices is now resorted to at high costs. It is therefore considered absolutely essential and urgent to develop matrix type designs on a crash development programme. The estimated development cost is Rs. 25 lakhs.

Development of Typewriter Keyboard and Computing Unit

The Hindustan Teleprinters at Madras are already manufacturing the standard typewriter type keyboard with a punch tape output. However, to suit the printing industry, it is necessary to modify the models for English and for different Indian languages, so that the tape output from this machine can be used as input for the phototype setter unit.

The main advantage of developing such an equipment will be to speed up the entire process of composing which at the moment is very slow due to the fact that the speed is limited by the operators' own speed. The divorcing of the keyboard from the type setting unit will be a definite technological advantage since this increases productivity for the entire printing industry. A simplified keyboard for Indian languages will make the equipment more versatile. The development cost is Rs. 10 lakhs.

Development of Photo-setting Unit

This unit consist of optical, photo mechanical and electronic devices. There are well known models of this type available in the world market. A few of these machines should be permitted to be imported for the purpose of understanding the working and then developed within India with suitable modifications. The development of computerised equipment would be for processing the tape into a tape output even to operate phototype setter or a hot metal casting machine. The estimated development expenditure is Rs. 20 lakhs.

Development of Plate-making Machinery

(a) Hydraulic matrix moulding machine.

(b) Finishing machines.

The above machinery is essential for making printing plates. All the items are at present being imported, but can be developed indigenously if RDD is encouraged. The estimated development cost is Rs. 5 lakhs.

Development of the Dark Room Type of Camera & Process Enlarger

Ordinary process cameras and enlargers are already being manufactured by some indigenous manufacturers and they should be encouraged to develop the more sophisticated equipment suitable for printing industry. The estimated development cost is Rs. 6 lakhs.

Development of Film Processing Equipment

The film processing equipment to be developed will be of a special type with some mechanical film handling equipment. These are now being imported. Manufacturers in India could now develop this. Estimated development cost is Rs. 1 lakh.

Development of Colour Scanners

These are highly sophisticated photo mechanical equipment with electronic application and are common for letter-press, offset and gravure processes. The development of this equipment is considered essential, in order to keep up with the increasing tempo of high quality printing in India. The estimated development cost is Rs. 15 lakhs.

Development of Powderless Etching Machine

Conventional etching of letterpress plates has given way to powderless etching because of the speed and superior results obtained on the latter machine. The designing of such a machine and the development of the chemicals, used for powderless etching, will be of immense value to all classes of printers. The estimated development cost is Rs. 5 lakhs.

Development of Litho Printing Down Frames & Litho Plate Coating Machines

These are essential items of equipment required by the lithographic printers. Although they are being made in the country in a small way, there is considerable scope for developing these indigenously on a larger scale. RDD should, therefore, be encouraged to develop these equipments on modern lines. The development expenditure is estimated to be Rs, 1.00 lakh.

Development of Automatic Platen Machine RA 3 size

A few hundred machines of non-automatic type are being produced in the country in the unorganised private sector. These are commonly used by small printers. There is an urgent necessity to develop an automatic machine, capable of accepting Indian standard RA 3 size paper and to encourage the indigenous manufacturers to increase their outputs to fill the gap that is likely to arise at the end of Fifth Five Year Plan. The estimated development cost is Rs. 5 lakhs.

Development of Letter Press Proof Press

There is an immediate necessity for development of semi-automatic precision proof press, of RA 2 size, to improve the quality of printing in the country. Although, there are a few manufacturers of ordinary hand proof presses in India, it is necessary to develop a semi-automatic type press of RA 2 size which will cater to the need of printers. The cost of the press is low and the estimated development expenditure is Rs. 2 lakhs only.

Development of Single Colour Sheet Fed Machine—RA 3 and RA 4 Sizes

RA 3 and RA 4 are very popular small size machines and there is immediate need of developing these in order to meet the needs of the small sections of the industry and the duplicating divisions in commercial offices, to work in conjunction with photostatic copying machines. For the development of these (RA 3 and RA 4 sizes) single colour machines, the estimated development cost is Rs. 10 lakhs.

Development of Offset Proof Press

Semi-automatic, RA 2 size, offset printing presses are considered important and necessary for immediate development. The estimated development expenditure is Rs. 5 lakhs.

Development of Folding Machines

Printed sheets for most uses, particularly for book and magazine production would have to be folded. It is therefore necessary to develop automatic and semi-automatic machines to handle such work. The development cost would be Rs. 3 lakhs.

Development of Perfect Machines

Millions of books nowadays are bound only in this fashion and this will be the type of binding likely to be adopted in greater numbers for the major portion of the pamphlets and for book production in the country. The development of such machinery is thus considered important. The cost of developing would be about Rs. 3 lakhs.

Development of Case Making Machinery

No work has been done so far on a machine of this type. All the case making is done by hand only. On account of the large demand, for bound books of all types, the development of a case making machine seems to be necessary. The cost of development is expected to be Rs. 3 lakhs.

Development of Gathering Machines

With the increase in literacy and compulsory primary education, the demand for bound school books of all types has reached enormous proportions. Gathering is one of the preliminary operations and the development of an automatic gathering machine will therefore be of considerable use to the book production industry. The cost of development is Rs. 5 lakhs.

evelopment of Wire Stitching Machine

This is a commonly used machine in the industry. Indigenous manufacture does exist t none of them has been found to be good enough for heavy duty stitching. The development st is expected to be Rs. 2 lakhs.

evelopment of Folding Machine

Printed sheets for most uses, particularly for book and magazine production would have be folded. It is therefore necessary to develop automatic and semi-automatic machines handle such work. The development cost would be Rs. 3 lakhs.

evelopment of Envelope Making Machines

Enormous quantities of printed stationery are being used and there is practically no agency at has tried to make automatic envelope making machines with and without printing arrangeents. Development of such a machine is therefore important. The estimated cost is about . 10 lakhs.

evelopment of Rotary Cutting and Creasing Machines

There is a large demand for this type of machine, because no heavy duty machine has so far en developed. It is necessary to develop this item indigenously. The estimated cost of developent is about Rs. 4 lakhs.

evelopment of Photo-Sensitive Materials for Graphic Arts.

Photosensitive materials for the graphic arts covering a wide range of films, thicknesses, nsitivity in terms of colour and speed form the very basis of the printing industry for reproduction type matter and illustration. Uptill now we have been depending on imports for reliable otographic material, involving considerable foreign exchange. The development of graphic art ms would, therefore, have to be given a very high degree of priority. Since a wide variety of aphic art films and materials have to be produced, it seems desirable to develop in the first stance, the most widely used items like process, orthochromatic and panchromatic films and ho films. The Hindustan Photo Films may screen all imports and if necessary channelise all ports to maintain uniformity and high quality. Simultaneously they should also develop manucture of these items independently and through well-known firms like Kodak, Agfa, Gaevert c., the agents for the supply of well-known imported materials. The development cost is timated to be about Rs. 25 lakhs.

evelopment of the following items:

Mounting bases, blocks, looking devices, plate registering devices, electronic sheet counting uipment, measuring and testing devices, anodisation of printing plates, polymer plates, photolymer plates, presensitized plates, paper masters, light sources including Xenon lamps etc., ve been recommended for development. The total development cost estimated is Rs. 50 lakhs.

evelopment of Packaging Machinery

A wide gap exists in this field. There is urgent need to develop packaging machinery. The dian Institute of Packaging, Bombay, is doing some work in the field. The estimates made by institute show that Rs. 125 lakhs will be required for development of packaging machinery ring the V Plan.

Setting up of Engineering Divisions in the Textile Laboratories & Other R & D Activiti

The functions of these engineering divisions will be :—

(a) To undertake the design and development of textile processes or machinery, parts, in cooperation with individual machinery manufacturers on a sponsorsh basis.

(b) To manufacture, in cooperation with sponors, prototype machines suitable f various conditions.

(c) To evaluate the performance of new machines under mill conditions and sugg measures for their improvement to the manufacturers.

(d) To investigate complaints from mills regarding defects in machinery and ma suitable suggestions for improvements.

The textile industry is to invest 1 per cent of its total turnover on RDD which w amount to Rs. 243 lakhs over a period of five years. The working group has recommende that an equal amount for five years may be contributed by CSIR.

50 per cent of the above sum may be used for setting up strong engineering divisions the textile laboratories of ATIRA, BTRA & SITRA and later in SASMIRA & IJIRA. T money so contributed will be used for building and maintaining the infrastructure of t engineering divisions in these laboratories. Machinery research is generally patentable resear and therefore developing individual machines or processes will have to be sponsored b individual manufacturers who will have the exclusive right to manufacture these machines and when they are developed. This would ensure participation between the manufacture machines and the research associations from the very early stage.

Total financial outlay is Rs. 243 lakhs.

Telecommunication & Power Cables Wires & Equipment RDD Institute

The need for the Institute is imperative for the following reasons :

1. There is at present no comprehensive collection of data on available level of technolo in the cable and wire industry.

2. The quality of products from many units is below appropriate standards and does n show any tendency towards improvement.

3. The position has been further aggravated by the fact that introduction of a high level of technology in most cases involves substantial new capital investment.

4. The level of available technology has remained quite low as industrial units in t cable and wire industry have not devoted practically any attention to RDD.

5. There exists no central organisation from which adequate technological informatio on products, processes and machinery can be obtained by any existing or potential entr preneur. There is also no organisation which keeps the latest information on level of technolog or trends in advanced countries.

The proposed Institute is to cover the entire innovation chain of RDD activity for cabl and wires, were ropes and plastics extrusion. The Institute will be responsible for initiating a aspects of RDD connected with the cables and wires industries and coordinating with all oth research organisations and manufacturing organisations.

The functional divisions of the Institute are as follows :

1. Dielectrics division
2. Metals division
3. Product division:
   - (a) Communication and high frequency except items covered by TRC.
   - (b) Power (underground, surface and overhead).
   - (c) General and special cables (signal control flexibles, mining and trailing cables, X-ray cables, Radar cables, Coaxial cables, Aircraft cables, cables for space crafts, High temperature cables etc.).
   - (d) Winding wires
   - (e) Wire ropes.
4. Machines division
5. Testing and proving division
6. High voltage division
7. Polymer division
8. Documentation division
9. Monitoring division
10. Project engineering division

The Institute will have about 200 scientists and engineers in addition to other supporting The institute should be located near cable manufacturing units which will facilitate tudies and proving of process and machinery.

Estimated rough financial outlay is Rs. 1000 lakhs

Besides, several specialised study groups to conduct surveys of indigenous capabilities otentialities of design and manufacture in cable and wire-making, (for both telecom and purposes), study of existing collaboration agreements or arrangements for furthering and isrng our techonological capabilities in wide areas and survey of RDD facilities in private ublic sector manufacturing units with a view to developing wires, cables and plastic ion, bimetallic and coated conductors etc., are required to be set up.

Funds required for surveys : Rs. 4.18 lakhs

(i) High speed 65 mm extruder.

Development of Extruders

The following three types of extruders are required to be developed urgently :

(i) High speed 65 mm extruder.

(ii) 90 mm extruder & cable coating machine.

(iii) 120 mm extruder & cable coating machine.

TC, Howrab, has already developed and supplied several extruders of 45 mm and n sizes They have the knowhow for development of the larger sizes of machinery mentioned above from M/s. Yamakewa Tekko Co. Osaka, with whom they are working collaboration.

These items are required for cable making machinery for manufacture of telecommu cation cables in public sector industries. Each cable making factory requires approximat 20 to 22 of these machines and it is expected that atleast 4 to 5 plants will be set up for manufacture of telecommunication cables in the public sector. The total financial outlay development of these machines has been estimated at Rs. 49.05 lakhs.

Development of Four Machines for Cable Making

1. HIGH SPEED PAPER INSULATING MACHINE

These machines are required in substantial quantities in future telephone cable factori In the 2nd cable factory of Hindustan Cables at Hyderabad, 90 such machines are bei imported. Each new factory will about 100 such machines. There is urgent need to devel these machines indigenously.

2. HIGH SPEED TWINNING MACHINE

20 such machines are being imported for the 2nd cable factory of Hindustan Cabl Hyderabad. Each new factory will require 20 to 25 such machines. Therefore these machin must be developed indigenously.

3. TRUNK CABLE INSULATING MACHINE

The 2nd cable factory of Hndustan Cables, Hyderabad is importing 4 such machin Each new factory is expected to need 4 to 8 such machines ; therefore, we must develop th machine in the country itself.

4. TRUNK CABLE QUADDING MACHINE

Such machine is being imported for the 2nd cable factory Hindustan Cables, Hyder bad. Each new factory is expected to need 3 to 4 such machines.

Total financial outlay : Rs. 16.12 lakhs.

Augmentation of RDD at TRC

There exist considerable gaps in technology in the field of telecommunication wires ar cables. With a view to reduce the gap in this vital field, it is necessary to undertake RDD. Tl nucleus exists in TRC and all RDD in the telecommunication wires and cables should be unde taken mainly by TRC and in selected areas by other agencies like HCL, and other cab units and NML and other laboratories.

In underground cables no work has been done for replacement of paper insulation polythene/foam polythene insulation. R & D in this field will be taken up by TRC in coll boration with cable making & appropriate plastic research institutes.

Similarly no work has been done for replacement of paper tape insulation by paper pu insulation. Other areas requiring R & D are : moisture barriers for plastic sheathed cable use of lower gauge copper conductors, use of aluminium alloy conductors or cables, use copper clad aluminium etc.

Total financial outlay : Rs. 66.4 lakhs.

Funds to Manufacturers for RDD

Although there are over 400 cable manufacturing units operating in the country, most of the units do not have proper technology. The quality of products, from many of these units, is of poor standards. The level of available technology has remained quite low as industrial units in the cable and wire Industry have devoted little attention to RDD.

This leads to the imperative need to do intensive RDD in the field of cables & wires. Several items have been identified for development at manufacturing units. Some of the items are listed below.

Accessories, dampers etc., aerial distribution cables, aluminium conductor cables for internal use, wire drawing machines, annealing equipment etc.

Total financial outlay : Rs. 446 lakhs.

Establishment of a Data and a Heavy Engineering.

At the moment, there is a wide gap in the country in dissemination of technical information, particularly in the field of Heavy Engineering. Technologies in the field of Heavy Engineering have been by and large imported from various countries. Whereas there exists some consolidation of data with the individual units, particularly, in their respective design organisations, no attempt had been made at national level to take complete inventory of available technologies and for collection, collation and cataloguing of the vast amount of information being generated in this field.

A "Data Bank" is highly essential for effective planning, for taking rational decisions regarding design and development of projects and equipment and also for evaluating needs for importing new technologies, for quick retrieval and dissemination of relevant data.

The functions and scope of the 'Data Bank' are as follows :

1. Acquisition, storage, retrieval and dissemination of all relevant technical information.
2. Evaluation of the status of available technical know how in the country in the field of Heavy Engineering. The evaluation is to be done regarding capability and capacity in the following areas of each discipline of Heavy Engineering :
   (a) Project design;
   (b) Equipment design;
   (c) Equipment manufacture;
   (d) Construction, erection & commissioning; and
   (e) Operation and maintenance.
3. Detecting gaps in the technical know how with respect to the technological advancement in the world.
4. Encouraging application of the latest technologies and processes in different disciplines of Heavy Engineering.
5. Preparation and publication of abstracts and reviews.
6. Providing enquiry facilities for the users.
7. Evaluation of literature in the field of Heavy Engineering for the purpose of capturing the relevant information.

8. Preparation of data sheets for use in planning organisations and design institutes.
9. Co-ordination and establishing links with units of Heavy Engineering for all related functions.
10. Providing a system of effective feed-back from all users.
11. Investigation of problems identified by planners and designers.
12. Provide translation facilities for technical literature in important foreign languages.
13. Duplicating facilities for the distribution of required articles to the users.
14. Research and development related to the latest techniques in information and retrieval systems.
15. Training facilities in the field of documentation and information retrieval systems. A few of these techniques are :
    - (a) Application of logic and methodological logic.
    - (b) Cybernetics.
    - (c) Information theory.
    - (d) Systems engineering.
    - (e) Library science.
    - (f) Reprographic techniques, etc.

The scope of work of the 'Data Bank' is as follows :

The field of Heavy Engineering has been divided into seven main categories.

They are : Heavy Electric Process Plant & Equipment, Chemical Process Plants and Equipment, Steel Plants, Mining Machinery & Ore Benefication Plants, Other Metallurgical Plants, Instrumentation & Control, and General Heavy Engineering.

Each category is further divided into different groups according to 'Specialised Technologies'. Data Bank is proposed to cater to the needs of all these categories of Heavy Engineering.

The 'Data Bank' is proposed to be under the Ministry of Science & Technology, and will have the following main divisions :

1. Data Abstraction.
2. Systems Engineering & Computer Centre.
3. Finance Division.
4. Personnel Division.

Total financial outlay : Rs. 1184 lakhs.

Data Centre for International Market Intelligence and Related Information

This Centre is essential for collecting information on the export potential of Indian machinery and for making surveys etc. Survey teams may have to be sent abroad for collecting data periodically.

Total financial outlay : Rs. 25 lakhs.

RDD in Oil & Water Drilling Rigs

The expert group has identified gaps in technology & design, and has suggested necessary measures. The development of water drilling rigs, tools and accessories is very important to give a boost to agriculture in arid zones.

There is also need to develop oil drilling rigs for drilling to depths of 6 Km. to 9 Km. Intense RDD efforts are required to develop new rigs for these applications.

Total estimated outlay : Rs. 100 lakhs.

Additional Projects

15 *MW Turbo-Generator for Fast Breeder Test Reactor being developed by Reactor Research Centre, Kalpakkam, Madras.*

It has been decided by the Government of India that one 15 MW Turbo-Generator for Fast Breeder Test Reactor should be developed by the RDD unit of Reactor Research Centre of Bhabha Atomic Research Centre, in Kalpakkam, who would take institutional responsibility. The specification is under discussion with RRC and as soon as it is finalised, design work is to be taken up for expeditious completion. This RDD Project is beneficial to the organisation as certain basic principles and concepts relating to the design of thermal generating equipment will be solved during this process.

Total financial outlay : Rs. 350 lakhs.

Pump Design and Development Unit

This Institute has been recommended by the NCST and the Task Force set up by the Planning Commission. It is also included in the DPR of BPCL. The development of special pumps for Fertilizer, Chemical and Metallurgical Industries and for handling fluids of all types of viscosities will be taken up by this institute.

Total financial outlay : Rs. 50 lakhs.

Establishment of Aluminium Application Centre

This has been suggested by NCST and Task Force. The centre will develop and propogate new & better uses & application of aluminium. The expenditure incurred by this Institute will be met by CSIR and industry on 1 : 1 basis.

Total financial outlay : Rs. 200 lakhs.

Development of Oil Drilling Rigs

Oil and Natural Gas Commission (ONGC) is negotiating with Heavy Engineering Corporation (HEC) for development of drilling rigs, to drill upto depths of 6 to 9 Km. HEC has expertise for drilling rigs upto about 5 Km. depth and they can take up the development of designs and manufacture of prototypes for higher capacity drilling rigs. If these are not developed indigenously large numbers will have to be imported. Therefore, the development of drilling rigs is very essential.

Total financial outlay : Rs. 20 lakhs.

6000*T Press Forgings*

There are considerable imports of forgings for turbine shafts and forged rolls. Now that the 6000T Press has been installed in the HEC, they are in a position to take up the forgings of turbine shafts and forged rolls. In addition, HEC has proposed to go in for ring rollings, in order to develop large size rings required in the heavy industry. It is estimated that approximately Rs. 1 crore will be required for these developmental activities after which imports worth several crores of rupees can be avoided.

Central Institute for Paper and Pulp Development including Facilities for Project Engineering of Paper Mills for Standardisation and Modification of Paper Making Machinery

There is almost a total lack of RDD activities for manufacture of newsprint, for handling project engineering for new plants to be set up during the 5th Plan, or for carrying out modifications in existing paper mills to produce paper to Indian Standard Specifications. The sizes of the paper being produced are widely varying with consequent loss in trimming to I.S. sizes. It is absolutely essential to modify the machinery in order to obtain I.S. size papers. The quality of paper is also very poor and there is considerable amount of RDD effort required in order to improve the same. RDD has also to be carried out for the utilisation of bagasse and other waste products for manufacture of paper. The use of non-conventional raw-materials should also be investigated. It is strongly recommended that the proposed RDD Institute for Paper Industry to be set up with UNDP assistance should widen its scope for RDD in paper making machinery also.

Funds required for RDD during the 5th Plan period : Rs. 160 lakhs.

Development of a 2000*T and* 100 *to* 150*T Cement Plants during the Fifth Five Year Plan*

A Cabinet Committee on Industry and Trade has suggested that it will be necessary to develop designs for cement plants of 2000T capacity so that such plants could be produced by the end of the 5th Plan and could be of a standardised size for the 6th Plan. The Cabinet Committee has also decided that a design of a mini cement plant of 100T to 150T capacity for location in appropriate places may also be taken up. The cement industry envisages a total plan expenditure of about Rs. 140 crores in the 5th Plan. RDD will have to be initiated for engineering plants of these sizes.

Funds required during the 5th Plan period for RDD including the manufacture of the prototype is estimated to be Rs. 2140.00 lakhs.

RDD in Automotive Ancillaries, Diesel Engines & Transport Vehicles

Automotive Ancillaries

Very little attention is paid to R&D in this field. Very few units have well equipped and established RDD units while the rest have only quality control facilities. A large number of ancillary units depend on public sector laboratories and test houses. It is suggested that cooperative research centres may be established in the country. For this purpose 1/2 per cent of the total turnover should be set aside for RDD. This amounts to Rs. 30 lakhs. A matching grant of Rs. 30 lakhs has been recommended to be made by the Government.

Diesel Engines

RDD activities in the industry at present are as a whole not very significant. Since investment in RDD is becoming expensive and individual units find it hard to incur heavy expenditure on RDD. It is suggested that a National Institute of Diesel Engine Development be set up. Such an institute would involve an outlay of Rs. 10 crores during the 5th Plan.

Total financial outlay : Rs. 10 crores.

Transport Vehicles

The quantum of money spent on RDD in the Transport Vehicle Industry is negligible in comparison with the total turnover of the industry. One of the reasons cited for this is the inadequate return on capital spent. It is necessary therefore to take positive steps for encouraging RDD activities. One of the remedies is to grant import entitlement of 20 per cent against exports, which will be used for procuring equipment, prototypes etc., for RDD. Besides the industry must set apart 2 per cent of turnover on R & D.

The total financial outlay estimated to be spent on RDD in automotive ancilliaries, diesel engines and transport vehicles is Rs. 1030 lakhs.

SECTOR—CHEMICAL INDUSTRIES

CHEMICAL INDUSTRIES

Indian chemical industry has grown rapidly during the sixties, recording highest growth es amongst the various industries in respect of gross block (440 per cent), total assets (384 per t) and sales (356 per cent). It contributes 7.2 per cent of the national capital employed in industries and 7.4 per cent of gross industrial output. The total investment in the chemical ustry has gone to nearly Rs. 2,200 crores by the beginning of this decade. This shows the id growth, taking into consideration the fact that the invested capital in the chemical indus- was only Rs. 304 crores in 1961 and Rs. 877 crores in 1966.

The chemical industry plays an important role in the national economy because of its ntribution to various other important sectors like agriculture, engineering, electronics, etc. e growth of fertilizer and plant protection chemicals is vitally important for the increased ricultural productivity and larger food and cash crop production. The drugs and pharmaceuticals ustry contributes in improving the health of the growing population and implementing pro- mmes concerning the population control. Production of synthetic and cellulosic fibres would ult in greater cloth availability. It would be possible to save on imports of cotton and/or release land for other crops like pulses and oilseeds which are in short supply. There are many non- rous metals and alloys which are being continuously replaced by technologically improved stic materials. The availability of packaging materials, like paper, jute, glass, and paper board being augmented by large supplies of these plastic materials. These new synthetic materials used engineering and packing industries are helping to meet the internal shortage of traditional terials, assisting import substitution and increasing the exports. The production of substantial antities of synthetic detergents would help us to save edible oils used in soap production and ich are required as food for the growing population. It will also help in reducing large volume import of tallow (Rs. 15—20 crores per annum) which would be necessary if we were to pend on the traditional cleaning agent like soap. The production of synthetic rubber would p us filling the gap between the availability and the growing demand of rubber for the fence and civilian uses.

The growth of the chemical industry has been much more accelerated in most of the veloped and developing countries due to rapid growth of markets of chemical products and h level of productivity of the industry. The same pattern of growth has also been found in case of lia during the sixties. In view of these factors, substantial increase in chemicals production l come up in the Fifth Plan period. There are certain important aspects concerning the chemi- industry which have to be borne in mind while planning for its further development. These :—

(a) The chemical industry is highly technologically oriented. The technological inputs in the industry and expenditure on research and development have been high in this industry in advanced countries as in the case of electronics, space, etc. If the Indian chemical industry has to become competitive and efficient, much greater emphasis on R & D will have to be put during the Fifth Plan period. This is all the more important as the technology has been generally imported in the sixties.

(b) Chemical industry has high rate of obsolescence. Competition between the various raw materials to produce the same end-products and between new processes: quest for improved conversion efficiency are major factors responsible for quick chang in technology. New processes are continuously being worked out and these develop ments result in improving the efficiency and productivity of the industry. It woul therefore, be necessary for the technological and scientific personnel employed withi and outside the industry to keep this important aspect of obsolescence in mind.

(c) Many sectors of chemical industry have now been recognised as sources of ra materials for a wide variety of secondary processing industries which provide a important outlet for substantial employment. The processing of plastics is alread employing more than a lakh of persons within the country. With future programme of increasing the plastic production three-fold from the present level of about 1 lak tonnes, employment potential would go up further. This is an industry which is widel dispersed and conducive to development in the small scale and medium scale sector Many industrially backward States within the country could start their process industrialisation by taking up fabrication and processing of these new synthetic ra materials produced by the chemical industry.

(d) The research in chemical industry consists of not only process development wor but substantial amount of research is also required to be done in the applicatio sectors. The synthetic resins; rubber and fibre manufacturers are developing cons derable know-how to demonstrate various and newer uses of these synthetic ra materials which are being produced by them. This application research helps th small and medium scale processing industries on the one hand by providing the technological inputs to improve the efficiency of their operation and on the othe hand it serves as an important feed back to the raw material manufacturing unit (synthetic resin fibres and rubber) to produce special grades of these materials t suit the individual end uses.

(e) The research in fertilizers and pesticides would involve large scale field trials. Combi nations of various fertilizers to suit the soil and climatic conditions and to hel specific crops have to be tried out before the most suitable formulations are evolve for individual areas and crops. Testing of soils and deep knowledge of plant growt are necessary for this research. Similarly, a detailed study of the diseases and insect affecting different crops (food and commercial) would be a part of the plan protection field research. Selection of the most suitable plant protection chemical and formulations have to be made after prolonged trials and experiments to asses efficacy, residual toxicity, immunity, etc.

The production of various categories of chemicals has already reached a level of abou Rs. 2,000 crores by 1972-73 (current value). The important segments of the Indian chemica industry are: petro-chemicals, polymers and elastomers; fertilisers and plant nutrients; inorganic chemicals and electro-chemicals; drugs and pharmaceuticals; dyes and intermediates; oils, fats soaps, detergents and surface coatings; and pesticides. All these areas have been studied by a panel of experts (numbering over 100) to identify both short and long term technological need of the Indian chemical industry.

5. The NCST Panel on Chemical Industry which set up 9 Planning Groups for differen subsectors has identified 241 projects for inclusion in the Science & Technology Plan. The tota cost of R & D inputs for 217 projects whose financial outlays are available comes to about Rs. 39.1 crores. A notional amount of Rs. 72 lakhs have been provided for the remaining 15 projects bringing up the total figure to Rs. 39.89 crores. 9 projects concerning fibres with R&D input of Rs. 32 lakhs have been shown in consumer industry sector. Further, a provision of Rs. 3 t 4 crores may also be needed for the technology groups to be formed in major public sector units t

similate and update the already purchased technology and develop design capabilities for new emical projects and for maximising production from the existing facilities.

The break-up of the outlay of Rs. 39.89 crores for the identified projects amongst the rious Ministries/Agencies is as follows:—

Ministry/Agency	Outlay (Rs. crores)
linistry of Petroleum & Chemicals	26.76
ouncil of Scientific & Industrial Research	12.04
.G.C. (Universities)	0.38
linistry of Education (Indian Institutes of Technology, including Indian Institute of Science, Bangalore).	0.26
ndian Council of Agricultural Research	0.29
linistry of Agriculture	0.16
TOTAL	39.89

Another vital area in which R&D problems have been identified on which the chemical dustry depends is the availability of an adequate scale of indigenous fabrication capability of lants and equipment.

So far, the R&D activity of undertakings in the public and private sectors of the chemical dustry has been marginal and mostly inhouse. The Science and Technology Plan now drawn p for the Chemical Industry is characterised by three important features:—

(a) Till now, the expenditure on various sectors on R & D was based on the programmes drawn up by the individual laboratories and had no bearing on the needs of the chemical industry. The S&T Plan now drawn up envisages an expenditure of about 35 per cent of the total R&D inputs on fertilizers and pesticides because these constitute an important segment of the chemical industry and are basic inputs for the agricultural productivity. Expenditure on petro-chemicals at 28 per cent is in keeping with the importance of this sector since it produces the new synthetic raw materials for many processing and fabricating industries. An outlay of 12 per cent on drugs and pharmaceuticals is in the context of the requirements of research needs of this sector for improving the health standards of our masses and stabilising the population at manageable levels. It will thus be seen that the Plan envisages about 75 per cent outlays on these three important sectors of the chemical industry.

(b) The Plan envisages for the first time an outlays of Rs. 3-4 crores for formation of technology groups with the objectives of maximising the production of various chemicals from the existing production facilities, assimilating the technology already purchased, developing design capabilities for expanding the chemical output by debottlenecking, expansion and setting up of new plants, and for delienating areas of R&D work for the development of indigenous technology.

(c) Substantial outlays for R&D facilities in the major public sector undertakings in the chemical industry have been envisaged. These constitute nearly 68.5 per cent of the total outlay envisaged under the Science & Technology Plan for the chemical industry.

A brief idea about the identified problems and the plan of work in each of the sectors is iven in the following paragraphs.

Bulk Organic Chemicals/Petro-Chemicals : The bulk organic chemicals manufacture as started in the early sixties. The production of these from the petro-chemical sources was however started in the second half of sixties. At present, two naphtha crackers in the priva sector in the Bombay region, ten synthetic resin manufacturing units, one synthetic rubb manufacturing unit and nine synthetic fibres manufacturing units contribute production worth Rs. 750 to 800 crores. Substantial increase in productic is anticipated in the next two or three years with the commissioning of the Gujar Petro-chemicals Complex. The current production of plastics is already more than 125,000 tonn and synthetic fibres and synthetic rubbers more than 25,000 tonnes each. The Gujarat Aromat Project has recently been commissioned. With the indigenous availability of important fib intermediate—DMT, substantial saving in foreign exchange has become possible. The plant Messrs Gujarat State Fertilizers for the production of caprolactam is likely to be commissione within the next year and this will enable production of the synthetic fibres based on indigenous available raw materials. The plants for production of these organic chemicals|petro-chemica have been based on technology purchased from abroad and substantial portion of the equi ment was also imported. The design engineering of most of these plants has been done t various foreign engineering firms.

The technological needs of these sectors consist of the following :—

(a) Developing and improving process data, design engineering, commissioning ar operational expertise for primary, secondary and tertiary petro-chemicals.

(b) Development of expertise for absorption of technology already purchased and pla ning for further production of these bulk chemicals by either expanding the existir facilities or setting up new facilities.

(c) Improving the technological efficiency of the production plants by better maintenanc production control, quality control, etc.

With a view to meet the above technological needs, certain important R & D proposal have been suggested. These include: setting up of an R & D Centre with an investment c Rs. 7.5 crores at Indian Petro-Chemicals Corporation Limited, Baroda. This Centr will have facilities for large size pilot plants to carry out work of high pressure/high temperatur polymerisations and other units operations. Facilities for application research in the field c fibres, synthetic rubbers and plastics will also be set up. The other important R & D project envisaged include those involving newer methods of manufacture of Terephthalic acid, caprolactam, cyclohexane, vinylchloride, phthalic anyhdride, maleic anyhdride, and hexachloro-cyclopentadiene etc. In case of some of these projects, larger outlays are involved because worl already done in the earlier years is being taken up at pilot plant or semi-commercial scale The development of technology for chlorinated and sulpho-chlorinated polyethylene i also proposed to be taken up. Other projects relate to process for the manufacture of melamin at atmospheric pressure, and development of oxo-synthesis technology. The development o technology for production of block copolymers of styrene and butadiene; terpolymers of ethylenc propylene and butylene and technology for manufacture of butyl rubber are envisaged in the synthetic rubber sector. The production of ethylene-vinyl acetate copolymers; moulding grad polyesters; polycarbonates, copolymers of styrene with acrylonitrile are proposed to be taken up in the plastics sector. The production of bi-component fibres of nylon, acrylic polysters anc polypropylene are envisaged under the synthetic fibres.

The Plastic Processing Centre at IIT, Madras is proposed to be strengthened anc capabilities in the application research field for producing different processed plastic goods will also be developed.

The total outlay for R & D inputs for the bulk organic chemicals is estimated at Rs. 11.18 crores. The work will be carried out at the R & D Centre of the Indian Petro chemicals Corporation and the National laboratories.

15. *Fertilizers and Plant Nutrients.*—Fertilizer production has already reached a level of 1.3 to 1.4 million tonnes (expressed in terms of nutrient-N/P_2O_5 etc.). The production is, however, substantially short even at the present low level of demand for fertilizers. The technological needs of the fertilizer industry are: (a) maximization of output from the capacity already planned; (b) speedy commissioning of new plants to fill up the gaps between the growing demand and indigenous production and (c) improving the technological efficiency of the plants and utilising indigenously available feed stocks and development of better catalysts, process chemicals, etc. The major projects envisaged in this sector are:—

(a)	High pressure gasification of solid fuels for direct manufacture of ammonia methanol oxo-synthesis gas.	(Rs. 550.00 lakhs)
(b)	Hydrogasification of coals for production of methano rich gas.	(Rs. 288.00 lakhs)
(c)	Benefication of low grade indigenously available rock phosphates.	(Rs. 151.71 lakhs)

The above three projects are aimed at utilisation of the indigenously available materials viz., coal and low grade rock phosphate. This will reduce dependence on naphtha/oil which are in short supply and imported rock phosphate.

Another important scheme envisaged in the R & D proposals is the application of anhydrous ammonia directly as a fertilizer so as to reduce the cost of the fertilizer input and improve the fertility of the soil. Some of the other projects are directed towards utilization and recovery of by-products like pyrite cinders; fluorine from fluorine bearing wastes; development and production of catalysts required for various manufacturing operations in the fertilizer industry. The total financial outlay for R & D projects in the fertilizer sector is Rs. 13.66 crores.

Inorganic Chemicals and Electro Chemicals.—The production of fertilizers, petrochemicals, dyes, explosives and fibres, etc. is dependent on cheap and adequate availability of the basic inorganic chemicals. There are about 330 units producing inorganic chemicals and the value of production of these chemicals is of the order of Rs. 165 crores. The R & D programme envisages the following major projects:—

(i) *Direct chlorination of ores*

Substantial gap exists between the demand and availability of titanium dioxide. Production of titanium by conventional method requires large quantities of sulphuric acid which needs import of sulphur. Direct chlorination of ilmenite to give titanium tetrachloride and its conversion into pigment-grade rutile titanium dioxide would result in substantial savings of sulphur and improve the availability of the pigment which is an important raw material for paints, plastics and other industries. Chlorination of other ores such as bauxite would yield aluminium chloride, an important inorganic chemical.

(ii) *Molecular Sieves*

The development of technology for these would enable indigenous production of an important material required in the organic synthesis and in the petro-chemicals manufacture.

(iii) *Dimensionally stable Electrodes*

The production of these electrodes will result in substantial saving in the imports of graphite electrodes presently used in the chlorine industry.

(ix) *Teflon*

Teflon is an important engineering plastic. It is heat resistant (up to 400°C) and unaffected by all known chemical agents except fused alkali. It is, therefore, used for permanen gaskets, seals, glass packings etc. The country's requirement of teflon is met by imports whic is worth Rs. 25 lakhs per year. The development of technology will result in saving of foreign exchange and creating indigenous capability for its manufacture.

Two schemes relating to Ion exchange membrane technology and its applicatio would enable development of technological capabilities for ensuring pure water supplies for th industrial plants. The total outlay for R & D projects for inorganic chemicals and electrochemicals is Rs. 2.70 crores.

Drugs and Pharmaceuticals.—The total production of drugs and pharmaceuticals ha increased from Rs. 10 crores in 1947 to Rs. 300 crores in 1971-72. Some of the majo problems of the pharmaceutical industry are :—

(a) Imbalance with respect to the production of basic drugs & pharmaceuticals require for formulations. The current consumption of drugs is valued at Rs. 75 crores, o which the indigenous production is worth about Rs. 50 crores necessitating th important of the remainder.

(b) Inadequate supply of raw materials and intermediates to attain the desired production levels.

(c) In adequate field trials to ensure extensive testing of the drug preparations propose to be formulated and marketed.

There is a heavy domination of foreign companies and foreign owned manufacturing units in the drugs industry. The technological task during the next 5 years would, therefore, require substantial inputs on the R & D side. One of the major projects envisaged is the setting up of a Fermentation Technology & Enzyme Research Centre at the Hindustan Antibiotics Ltd. (HAL), Poona. This area has tremendous potential for industrial growth and also plays an important role in the country's health programme by way of use of antibiotics. The HAL is already spending around Rs. 25 to 30 lakhs a year on R & D and has developed laboratory processes for several industrial enzymes as well as new antibiotics. Support to HAL efforts is likely to yield attractive returns in comparatively short time. Other projects proposed to be taken up relate to newer routes for synthesis of important drugs and pharmaceuticals, such as ephedrine, glutamic acid, vitamins etc. In addition, a planned programme for the cultivation of aromatic plants for extracting perfumery aromatics and gums used in pharmaceutical preparations have also been proposed. The R & D inputs for this sector is envisaged at Rs. 4.83 crores.

Dyes and Intermediates.—The production of dyes is a post-independence development. During the last 25 years, India has got itself into the first ten dyes producing countries of the world. The present production of dyes in India is of the order of 17,000 to 18,000 tonnes, valued at about Rs. 75 crores. Though the production in initial stages was based on imported technology, equipment and raw materials, the development of indigenous capability has, perhaps, been the fastest in this sector. A large number of dye-stuff intermediates are now being produced within the country and dependence on imports of raw material has been reduced from 50 to 60 per cent in early sixties to about 10 to 12 per cent in 1972.

Indian dyestuffs industry has started exporting dyes and intermediates during the last three to four years and the exports have reached a level of about Rs. 5 crores per year. Many eveloped countries are giving up manufacture of dyestuffs intermediates because of economic nd other reasons. The manufacturing process of these intermediates involves handling of xplosive, inflamable and toxic raw materials, vigorous production and quality control. Because f these difficulties, the dyestuffs intermediate manufacture has become to be comparatively less tractive in the developed countries and the emphasis has shifted to production of plastics and ulk organic chemicals. The export prospects for dyestuffs and intermediates have, therefore, ubstantially increased.

The technological needs of the dyestuffs industry mainly relate to indigenous availability f key raw materials and development of knowhow for newer class of dyestuffs. It is proposed o create infra-structure facilities for R & D for development of technology for manufacture of ntermediates required by the dye-stuffs, pharmaceuticals and pesticides industry at the Hindustan Organic Chemicals Ltd. Rasayani. Out of the various projects suggested a few of the important ones are : maleic anhydride, niacinamide, toluene, diisocyanate, toluene diamine, anthraquinone and carbazole. The total outlay for the R & D projects in this sector is estimated at Rs. 4.79 crores.

Oils, fats, soaps, surfactants, paints and varnishes.

(i) *Oil and fats.*—India is one of the leading oilseed producing countries in the world and a major part of these used to be exported. With the general growth in the industrial deveopment, the exports of seeds were gradually curtailed to meet the domestic need. The producion of fatty oils during the year 1971-72 was 3 million tonnes but the demand overstripped the supply necessitating huge imports of oils valued at Rs. 50 crores in foreign exchange. The per capita consumption of oil in India was roughly at about 3.2 kgs. in 1960-61 and even today, the consumption has remained at this level. This may be compared to the desired nutritional level estimated at 22 kgs. per year. Retaining the consumption at 3.2 kgs. per year, a deficit of 8.7 lakh tonnes estimated at today's prices would cost about Rs. 150 crores in foreign exchange. The fats and oil based industries derive their importance from catering to the basic needs of common man by providing wholesome nutritious products, removal of dirt and contamination and protection against natural weathering. The industry serves as a feeder to other industries such as vanaspati, soaps, and surface coatings. The total production of edible oils during 1971-72 was estimated at 3 million tonnes valued at about Rs. 340 crores. Seventy per cent of the total production related to groundnut oil and rest was made up of oil from mustard, sesame, linsed and castor seeds.

(ii) *Paints & Varnishes.*—The production of paints and varnishes in 1971 amounted to about 66,000 tonnes valued at Rs. 28 crores. Of the 17 units in the organised sector, 8 units account for nearly 75 per cent of the total production and of this 60 per cent was produced by the foreign owned companies. There are 250 small scale units accounting for an annual output of 25,000 tonnes valued at Rs. 10 crores. The paint industry is raw material intensive and with the un-interrupted availability of some of the key materials like mineral turpentine, glycerine and linseed oil, the total production can be expanded considerably.

The technological needs of this sector are (a) increasing the source of edible oils for greater oil production; (b) development of fat based products for better nutritive value, greater stability and wider acceptability; (c) processing techniques for obtaining edible grade proteins from oil seeds; and (d) development of alternative sources of raw materials for the paints industry. One of the major schemes identified under this sector is the economic utilisation of rice bran and its products. It is estimated that 4.80 lakh tonnes of rice bran oil can be obtained from the available bran but the present production is limited only to 39,000 tonnes. The project envisages inexpensive method for stabilisation of rice bran oil and recovery and utilisation of rice bran wax. This project will augment the supply of oils which are in short supply.

Other projects include surfactants based on cardanol, castor oil and other indigenous materials; development of catalyst for hydrogenation of oils; and better utilisation of non-edible oils, etc. The total R & D outlay envisaged for 7 projects comes to Rs. 21.47 lakhs.

Pesticides.—As pointed out above, pesticides are among the important inputs for increasing agricultural production. Currently India is producing 39 products in technical grade comprising of 22 insecticides, nematocides, rodenticides and fumigants; 14 fungicides and 3 herbicides. In 1971-72, as against the installed capacity of 41,258 tonnes, the production of technical grade pesticides was 25,678 tonnes. The capital invested in pesticide industry today is estimated at Rs. 16 crores. To meet the increasing demand for pesticides, India spent Rs. 10.25 crores in 1971-72 for import of pesticides and their raw materials. The corresponding figure for 1973-74 is expected to be around Rs. 19 crores. With the acceleration of agricultural programmes aimed at increasing food production through intensive cultivation, there will be increasing demand for pesticides.

The immediate need of the pesticides industry is development of technology for a wide range of compounds currently imported; development of fungicides for special crops like cotton, pulses, fruits, seed-dressing: finding substitutes for pesticides which have high residual toxicity and development of technology for newer pesticides for future use. Among the R&D projects envisaged is the development of organophosphorus pesticides; endosulfan, aldrin and benomyl. Basic research in juvenile harmones and herbicides based on phytotoxins which is already in progress is proposed to be further supported. These researches are likely to lead to the development of biologically active non-toxic chemicals which will reduce pollution hazards involved in the use of present range of pesticides. The total R&D outlay envisaged for the development of pesticides amounts to Rs. 61 lakhs.

Marine Chemicals.—This segment of the Indian Chemical Industry has not developed to an extent where fuller utilisation of marine resources and recovery of marine chemicals as well as marine pharmaceuticals could be made. As is well known, the major constituents of sea water are sodium chloride, magnesium chloride, magnesium sulphate, calcium sulphate, potasium chloride and bromine. Sea weeds also serve as an important source of chemicals such as alginic acid, agar agar, proteins and iodine. Hitherto, no systematic effort has been undertaken to establish a marine resources based chemical and pharmaceutical industry in the country.

Eight projects at a total cost of Rs. 83.75 lakhs have been identified under this sector. These include; study of chemistry and pharmacology of extractions from marine flora and fauna; bromine from bitterns brines and sea water; fortification of common salt with calcium, iron and iodine, recovery of potash, magnesia of different grades, application of ion exchange membranes in electrodialysis; desalination through reverse osmosis; recovery of iodine and chemicals from sea weeds. As regards the scheme relating to fortification of salt with calcium, iron and iodine, it may be pointed out that although India exports sizeable quantities of common salt, this industry is becoming highly competitive. The exports are being threatened for want of better techniques of production as well as quality which is below international standards. Fortification of salt with iron is a programme which is exceedingly important for reducing the incidence of anemia caused by iron deficiency amongst the poorest sections of the society. It is proposed to support research effort connected with these problems aimed at strengthening the salt industry on the one hand and fortification of salt with iron and other nutritionally important elements. A total outlay of Rs. 83.74 lakhs is envisaged for this sector.

Chemical Engineering Research and Design Capability Development.—In a highly capital intensive industry such as chemicals, the problem of plant construction has assumed increasing importance. The speed of technological change, the dramatic increase in the unit ze and the growth in the construction of single stream plants call for greater care in designing, brication and integration of components so as to meet the chances of successful early operations. here are areas in the field of chemical engineering and design which need much greater tention in India to develop competence. Several projects which appear critical for chemical ant design have been proposed. Specifically, the areas of work proposed relate to fluid-fluid ontractors; liquid-liquid extraction relating to metallurgical field and extraction with quidation exchange; pipe line transportation, fluidised bed dryers, etc. Liquid-liquid extraction pro- ss proposed to be developed will result in better recovery and separation of important non-ferrous etals like copper, nickel, cobalt, vanadium and tungsten. Fluidised bed dryers are the most odern dryers suitable thorough and intimate drying of materials like ores, fertilizers, coals, ains like wheat, paddy etc. The total financial outlay envisaged for various projects amounts Rs. 35.67 lakhs.

The break-up of the expenditure for the various segments of the chemical industry is ven below :—

l. No.	Planning Group	Financial Outlay (Rs. lakhs)
1.	Bulk Organic Chemicals/Petro-chemicals, Polymers	1,118.33
2.	Fertilizers and other Nutrients	1,365.91
3.	Inorganic Chemicals and Electro-chemicals	269.95
4.	Organic Fine Chemicals, Drugs and Pharmaceuticals	482.75
5.	Dyes, Intermediates for Dyes and Pharmaceuticals	478.90
6.	Oils, Fats, Soaps, Surfactants, Paints and Varnishes	21.47
7.	Pesticides	61.05
8.	Marine Chemicals	83.74
9.	Chemical Engineering Research and Design Capability Development	35.67
		3,917.77
	Projects for which financial inputs have not been indicated.	72.00
	TOTAL :	3,989.77

SECTOR : CHEMICAL INDUSTRIES

The projects identified by the various Planning Groups are as follows :—

Sl. No.	Title of the Project	Financial Outlay (Rs. lakhs)
1	2	3
Development of Process/Product		
	G₁—Bulk Organic chemicals/Petro-chemicals, Polymers	
$S_1G_1P_1$	Terephthalic acid	
	(i) Oxidation of p-xylene	
	(ii) Disproportionation of benzoic acid	8.00
	(iii) Oxidation of p-xylene in absence of bromine	
2.	Caprolactam	
	(i) from benzoic acid	9.30
	(ii) from benzene	3.00
3.	Disproportionation of toluene to benzene and xylenes	2.50
4.	Long chain alcohols	4.60
5.	Oxo-synthesis	30.00
6.	Vinyl acetate	1.50
7.	Cyclohexane from benzene	9.70
8.	Microencapsulation	5.00
9.	Microbial conversion of petroleum hydrocarbons	17.30
10.	Molecular sieves	20.53
11.	Adipic acid	2.00
12.*	Chemicals from natural gas	6.00
13.	Methyl ethyl ketone	4.00
14.	Newer mehods for phenols	3.00
15.	Synthetic tartaric acid	7.30
16.	Butadiene from butene	5.00
17.	High analysis nitrogenous organic compounds based on urea etc.	4.40
18.	Melamine at atmospheric pressure based on urea	26.40
19.	Continuous fractional crystallisation	4.50
20.	Hydroformylation of olefins	36.00
21.	Vinyl chloride	4.00
22.	Phthalic anhydride	3.00
23.	Methanol	7.00
24.	Methylamines	8.00
25.	Styrene and ethyl benzene	6.00
26.	Propyl and isopropyl amines	N.A.
27.	α-Naphthol	3.00
28.	β-Naphthol	1.00
29.	Isopropanolamine	N.A.
30.	Aniline	N.A.
31.	Amyl and isoamyl alcohols	2.50

1	2	3
G_1P_{32}.	Cyclohexylamine	3.00
33.	Chloromethanes	N.A.
34.	Detergent alkylates	4.50
35.	Ethylene oxide	2.00
36.	Ethylene glycol	3.50
37.	Ethanolamines	4.50
38.	Epichlorohydrin	3.00
39.	Glycerine (synthetic)	4.00
40.	Hexachloropentadiene	3.50
41.	Isopropyl alcohol and its derivatives	4.00
	Polymers and Elastomers	
42.	Chlorinated polyethylene, sulpho-chlorinated polyethylene, metal containing polymers etc.	8.00
43.	Block copolymers of styrene and butadiene	6.00
44.	Terpolymers of ethylene, propylene and butylene	8.00
45.	Butyl rubber	18.00
46.	Synthetic paper	3.50
47.	Acetal resins	9.50
48.	Ethylene-vinyl acetate copolymer	4.00
49.	Moulding grade polyesters based on butylene, ethylene-glycol and terephthalic acid	6.00
50.	Polycarbonates	5.00
51.	Copolymers of styrene with acrylonitrile, methyl methacrylate, methyl styrene and terpolymer with acrylonitrile and butadiene	N.A.
52.	Acrylate-maleic anhydride copolymer	N.A.
53.	Vinyl chloride vinylidence chloride copolymer	N. A.
54.	Studies in sulphur corrosion in hydrocarbon processing	0.80
55.	R&D Centre for Plastic Processing	7.00
56.	Infrastructure facilities for fibres	16.00
57.	R&D Centre at IPCL	750.00
58.	Improvements in spinning	N.A,
	TOTAL G_1	1,118.33

G_2—Fertilizers and Other Nutrients

G_2P_1. *	Reuse of by-product phosphogypsum for recovery of sulphuric acid and cement	7.5
2. *	Recovery of sulphur from by-product phosphogypsum	0.80
3. *	Utilization of Fly ash	2.8
4.	High pressure gassification of solid fuels for direct manufacture of ammonia/methanol/oxo-synthesis gas	550.0
5.	High pressure hydrogassification of coals for production of methane rich gas and high pressure hydrogen	8.0
6.	Development of an alternative reduction oxidation of iron oxide with producer gas and steam in fluid bed system and under pressure.	22.53
7.	Application of anhydrous ammonia as a fertilizer	62.25
8.	Beneficiation of low grade rock phosphates	151.71

$S_5G_2P_9$.	Suitability of different types of rock phosphates resources in India for production of phosphatic fertilizers.	14.5
10.*	Utilisation of pyrite cinder obtained as by-product from pyrite based sulphuric acid plants*	26.
11.*	Recovery of fluorine from fluorine bearing wastes of phosphatic fertilizer and chemical industries.	16.5
12.	Hydrazine cracking catalyst	10.3
13.	Substitute for platinum catalyst for oxidation of ammonia to nitric acid . . .	13.6
14.	Hydrorefining catalyst based on indigenous raw materials	16.1
15.	Deoxo catalyst based on indigenous raw materials	16.2
16.	Pre-reforming catalyst	13.5
17.	Simulation and on-line optimal control of an ammonia plant	7.5
18.	Development of advanced non-destructive testing techniques for evaluation of engineering materials and plant equipment related to fertilizer and heavy chemical industries.	8.0
19.	Pressure vessels evaluation by experimental stress analysis under simulated loading	6.0
20.	Evaluation of service defects on a few specific equipment of fertilizer/chemical plants by specially developed NDT techniques.	3.0
21.	Studies on vibration levels association with service deteriorations of high speed rotary machines and related equipment used in fertilizer/heavy chemical industry.	17.5
22.	Design and fabrication of an instrument for rapid non-destructive estimation of ferrite in austenitic stainless steel.	1.83
23.	Extraction of phosphoric acid from rock phosphate using ammonium sulphate in a cycle .	15.50
24.	Development of comprehensive process for the production of different types of alumina and aluminium compounds required for industrial uses.	34.12
25.	New technique of remote control of electrical capacitances	5.10
26.	Preparation of super phosphoric acid and ammonium polyphosphate	2.50
27.	Use of ammonium bicarbonate as a fertiliser	10.00
28.	Super high analysis fertilizers	N.A.
29.	Nitrogen fixation by transition metal complexes and reduction of the same in the available form.	15.04
30.	Nitrification inhibitors for soil application	9.80
31.	Development of pilot plant for the mass culture of blue green algae (Bio-technology of algae culture).	11.50
	TOTAL G_2	1,365.91

G_3—Inorganic Chemicals and Electro Chemicals

$S_5G_3P_1$. *	(i) Chlorination of ores (such as bauxite and ilmenite) . . . . (ii) Vapour phase oxidation of titanium and silicon (tetrachloride) halides to their oxides	86.00
2.	Dimensionally stable electrodes	19.50
3.	Polytetrafluoroethylene (Teflon)	30.60
4.	Silicones	4.90
5.	Manufacture of copper sulphate directly from sulphur bearing copper ores like chalcopyrite.	2.30
6.	Organometallics (Tin and Titanium organics)	7.70
7.	Sodium hydrosulphite from sodium formate	2.60
8.*	Recovery of zinc from zinc hydroxide-(by-product of the present process for the production of sodium hydrosulphite.)	9.20

Projects concerning fibres have been included in Consumer Industry sector.

1	2	3
9.	Electro-thermal products involving the design of improved types of furnaces and utilisation of indigenous low grade raw materials.	43.00
10.	Preparation of electroinorganic/organic chemicals of commercial importance; permanganates, perchloric acid, lead chromate etc. Hydroxylamine sulphate, Ferro-ferricyanides, perborates and percarbonates, hydroxy-lamine hydrochloride, lithium hydroxide and other compounds.	12.00
11.	Ion exchange membrane technology and its application	40.09
12.	Hydrazine hydrate	2.70
13.*	Recovery of sulphur from Gypsum	9.36
	TOTAL G3	269.95

G4—Organic Fine Chemicals, Drugs and Pharmaceuticals

$_5G_4P_1$.	L-Ephedrine	1.50
2.	Lysine	1.50
3.	Glutamic acid	3.50
4.	Vitamin B_6	1.25
5.	α-Methyl dopa	1.50
6.	L-Dopa	1.25
7.	Indomethacin	2.00
8.	Vitamin E	2.50
9.	Furoseamide	2.00
10.	Metronidazole	1.25
11.	Chloroquin and Amodiaquin	5.50
12.	Caffeine, Theophylline and Aminophylline	2.50
13.	Oxytocin	0.75
14.	p-Aminobenzoic acid and benzocaine	2.50
15.	8-Hydroxyquinoline	1.50
16.	n-Propyl isocyanate	1.00
17.	Novoldiamine	2.00
18.	Dietyl ethoxymethylenemalonate	0.75
19.	Butyl and propylamines	2.00
20.	7-Dehydrocholesterol	1.50
21.	Thymol synthesis	2.00
22.	Coumarin	1.00
*23.	Slaughter house products-insulin and pancreatin	6.30
*24.	Fatty acids, alcohol and stigmasterol from sugarcane press-mud	5.00
25.	Filteraids	2.00
26.	Vanillin and ethyl vanillin	1.20
27.	Fermentation Technology and Enzyme Research Centre	326.00
28.	Oil of mentha piperita	3.50

1	2	3
29.	Oil of mentha spicata	0.50
30.	Lavender oil	3.50
31.	Lavendine	1.00
32.	Eucalyptus citriodora oil	1.00
33.	Cin. leaf and allied oils	4.00
34.	Geranium	4.00
35.	Patchouli oil	1.50
36.	Citrus peel oil	1.00
37.	Citrus leaf oil	0.50
38.	Citronella oil	5.00
39.	Mentha arvensis oil	5.00
40.	Mentha citrata oil	0.50
41.	Ajowain and anethi oil	1.00
42.	Lemongrass oil	11.00
43.	Vetiver oil	1.00
44.	Palmarosa oil	1.50
45.	Cedar wood oil	0.50
46.	Guar gum	13.00
47.	Karaya gum	10.00
48.	Tamarind seed gum	0.50
49.	Psyllium seed gum	6.00
50.	Ghatti gum	0.90
51.	Gum arabic	1.60
52.	Pyrethrum	7.00
53.	Dioscorea sp.	3.50
54.	Atropa belladona and acuminata	2.50
55.	Claviceps purpurea	2.50
56.	Glycyrrhiza glabra	2.00
57.	Ipecac	2.50
58.	Papaver somniferum	2.50
	TOTAL G4	482.75

G 5—Dyes, Intermediates for Dyes and Pharmaceuticals

$S_5G_5P_1$	Technical Preparation of alkylated phenol derivatives like ptert butyl catechol, p-tert octyl phenol, butylated hydroxy anisole, p-tert butyl benzoic acid.	7.40
2	Utilization of by-product iron oxide	N.A.
3	Dimethyl formamide	3.00
4	Dimethylacetamide	3.20
5	Maleic anhydride involving air oxidation of benzene	4.00
6	Niacinamide by oxidation of β-picoline	2.60

1	2	3
7	Anthraquinone from oxylene by air oxidation . . .	8.00
8	Toluene diisocyanate	13.00
9	Alkyl acrylates such as methyl acrylate from acrylonitrile . .	4.50
10	Technical preparation of dicyandiamide, guanidine and melamine .	6.00
11	Toluene diamine	4.50
12	Cresylic acid and cresols and methyl ethyl ketone (MEK) as a by-product.	4.85
13	Sulfolane	4.00
14	Intermediates for rubber chemicals diphenylamine, 4-nitrodiphenylamine and 4-aminodiphenylamine.	3.00
15	Acetylacetone as intermediate for sulphadimidine . . .	4.85
16	Chemicals derived from glycol and diethylene glycol . .	4.00
17*	Anthracene, anthraquinone and carbazole	4.50
18	Cyanuric chloride	2.50
19	Dyes for synthetic fibres such as polyester, polyamide, polypropylene and acrylic fibres.	30.00
20	Dimethylaniline from aniline and methanol by a continuous process at atmospheric pressure.	1.95
21	Ethylene diamine	N.A.
22	Phthalonitrile from o-xylene or naphthalene	N.A.
23	p-Nitroaniline by aminalysis of chloronitrobenzene . .	1.95
24	Electrochemical preparation of sebasic acid . . .	4.00
25	Adiponitrile by cathodic dimerisation of acrylonitrile . .	7.00
26	Infrastructure facilities for R&D at HOC	350.00
	TOTAL G5	478.80

G 6—Oils, Soaps, Surfactants, Paints and Varnishes

S5G6P1	Economic utilisation of rice bran and its products (a) Inexpensive method for stabilisation of rice bran (b) Refining of rice bran oil (c) Recovery and utilisation of rice bran wax	8.72
2	Surfactants based an cardanol, caster oil and other indigenous materials.	2.93
3	Catalyst for continuous hydrogenation of oils	2.97
4	Studies on preparation of catalysts for the hardening of oils . .	4.02
5	Short chain mono and dibasic acids	2.83
6	Aflatoxin removal from oil seed meal particularly groundnut .	N.A.
	TOTAL G6	21.47

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*These projects relate to utilisation of wastes and also included under the Panel on Recycling of Wastes.

1	2	3
	G 7—Pesticides	
$S_5G_7P_1$	Organophosphorus pesticides	10.00
2	Endosulfan, Aldrin etc.	7.00
3	Lindane, high γ-BHC	2.00
4	Kelthane	1.00
5	Methoxychlor	1.00
6	Tetradifon	1.50
7	PCNB	1.00
8	Benomyl	5.00
9	Vitavax	2.50
10	Hinosan	2.50
11	Paraquat	2.50
12	Dalapon	2.50
13	Nemagon, Nemex	2.50
14	Formulation of pesticides	5.00
15	Synthetic Juvenile Hormones	3.50
16	Mode of action of insect hormones	3.20
17	Herbicides based on phytotoxins	1.50
18	Neurotoxins of insects	4.35
19	Natural and Synthetic pheromones	N.A.
20	Insecticides	N.A.
21	Pesticide-polymer combinations	1.00
22	Synthetic pyrethrins	1.50
	TOTAL G_7	61.05
	G 8—Marine Chemicals	
$S_5G_8P_1$	Study of chemistry and pharmacology of extractives from marine flora and fauna.	15.00
2	Bromine from bitterns brines and sea water by steaming out and blowing out techniques.	8.85
3	(a) Salt for industry and export	12.51
	(b) Fortification of salt with calcium, iron and iodine	
4	(a) Recovery of potash from sea bittern either in the form of schoenite, sulphate and other fertilizer salts.	7.98
5	Recovery of potash from subsoil brines in Great Rann of Kutch	10.82
6	(a) Magnesia of different grades from sea water bittern	9.17
	(b) Magnesium chloride electrolytic grade for the preparation of magnesium metal.	N.A.
7	Desalination, concentration and separation of chemicals and water treatment problems by reverse osmosis.	13.52
8	Recovery of iodine from indigenous iodine bearing sea weeds, sea plants and other iodine bearing raw materials.	3.60
9	Chemicals from economic sea weeds Agar-agar	2.29
	TOTAL G_8	83.74

1	2	3
	G 9—Chemical Engineering Research and Design Capability Development	
S5G9P1	Fluid-fluid contractors for liquid-liquid extraction as related to metallurgical field.	2.84
2	Fluid-fluid contractors for liquid-liquid extraction with exchangers.	2.26
3	Transport through pipelines	12.10
4	Studies in development and designing of mixers for processing high viscosity, Newtonian and Non-Newtonian materials.	1.80
5	Development of fluidized bed dryers	2.09
6	Distillation column reactors	4.40
7	Development of fluidized beds	7.04
8	Condensation of mixed vapours resulting in two liquid phases	1.57
9	Condensation of vapours at low pressures	1.57
	TOTAL G9	35.67

SECTOR—CONSUMER INDUSTRIES

CONSUMER INDUSTRIES

Consumer Industries cover a wide range of subjects of interest to the common man. Seven Planning Groups on the following subjects, *viz.* Textiles, Food, Sugar, Leather, Salt, Camera nd Photographic Chemicals and Tobacco were formed under this Panel. Thus, out of the hree primary requisites of man, namely, food, clothing and shelter, the first two aspects are overed under this Panel.

The total projects identified by the Panel number about 300 and the overall outlay for hese projects comes to about Rs. 49 crores including a foreign exchange component of Rs. 7 rores. The implementing agencies for these projects include Ministry of Agriculture, Ministry f Commerce, Ministry of Industrial Development, CSIR, ICAR, etc. The total financial esources required from the governmental agencies for implementation of these projects come o only about Rs. 42 crores. The contribution of the private sector to the cooperative research nstitutions like ATIRA, IJIRA and SASMIRA comes to about Rs. 7 crores. A summary of he financial outlay required for the various groups is attached. The RDD projects identified y them are delineated in the following paragraphs.

TEXTILES

The Task Force on Textiles set up by the Planning Commission has stated that because f imbalances in income distribution among the population, the per capita consumption of loth of the weaker section accounting to 40 per cent was as low as six metres till a few years go. It is also estimated by the same Task Force that the average per capita availability of cloth n 1972 has been of the order of 13.2 metres of cotton cloth and 1.8 metres of man-made fibres tc., and that this should increase to 13.6 metres and 3.7 metres respectively in 1978-79, for a opulation of 639 million. In light of this, the work of the Panel revolves around aiding he industry in its task of reaching these goals and to provide at least a pair of durable and ashable clothes to the weaker sections of the community, uniforms for poorer sections of orkmen, school going children etc., cater to agewise and regionwise requirements, giving protection from cold weather in the areas where it is necessary etc.

We have also to remember the overall interests of the country in terms of availability of aw materials and sophisticated textile plant and machinery, minimising their imports and aximising exports by taking advantage of the gradual withdrawal of developed countries from hese fields due to labour intensive nature of these industries.

It then becomes clear that, while catering to the weaker section, maximum attention is to e given to the cotton textile industry from the point of view of avoiding excessive imports of otton, releasing fertile lands for food production rather than for cotton, obtaining durable wear ffording protection from cold weather, promoting export etc., cellulosic and man-made fibres, ool and jute occupy an important place in the economy. There is growing competition to jute rom synthetics in the field of packaging and new uses have to be found for them.

Accordingly sub-groups were formed to identify RDD projects in the following areas:

(i) Cotton Textiles and Blends,

(ii) Synthetic Fibres,

(iii) Wool,

(iv) Jute Products/Process technology and Machinery Development,

(v) Agricultural and Genetic Research on Jute.

(i) *Cotton Textiles and Blends*

According to the Planning Commission Task Force on Textiles, at the end of the Fourth Plan, the availability of cotton cloth for domestic consumption and exports was expected to be 8,750 m. metres, the actual availability coming down to 8,000 m. metres. The corresponding figures projected for the last year of the Fifth Plan is 10,040 m. metres, reflecting an increase of 25.5 per cent over a 5 year period.

While projects for improving cotton production to reach the above targets are being taken care of by ICAR and other agencies, the projects identified by this sub-group, to meet the target envisaged, range from evaluation of Indian cottons and improving ginning practices to methods of increasing yarn production rates like rotor spinning and twistless spinning and designing and development of machinery. Warp knitting is another project which would open out an entirely new field of work. Some of the projects attempt at winning consumer acceptance by eliminating the factors which give rise to yarn faults and yarn irregularities. Colour matching by computer is a project which would help to reduce cost of dyeing textiles by prediction of dyeing recipes with the help of computer programming. Investigations for imparting certain desirable properties to cotton and silk and development of flame retardant finishes have been proposed. New and useful properties of cotton are to be obtained by various chemical means. Research and development in testing instruments and process control systems would be helpful in import substitution.

In the field of design of textile manufacturing machinery, we are still quite backward and therefore, strong engineering divisions are proposed to be set up in the Textile Research Associations like ATIRA, BTRA, and SITRA. The group set up for this purpose by the Panel on Heavy Engineering has suggested in its report that this may be achieved by Government and industry cooperating together as at present in the case of institutions at ATIRA, BTRA and SITRA. The industry shall contribute a matching sum. Assuming the turnover of the machinery manufacturers at Rs. 40 crores per annum, a growth rate of 10 per cent per annum and 1 per cent contribution on this turnover, a sum of Rs. 243 lakhs would be the share each of Government and the industry in 5 years. This can go a long way in the proposal for strengthening the engineering division of the textile laboratories. Creation of a pool to finance fabrication of prototypes has also been suggested as an adjunct of this project.

Another scheme of considerable magnitude is the proposal to set up technical service centres for powerlooms. The sub-group has studied the concentration of powerlooms in various states and is of the opinion that, to start with, one each of these should be set up at least in 8 states. These centres will test the grey and sized yarns for various properties and advise the weavers in maintaining the machinery in its proper condition. The cost of each centre would be about Rs. 13.25 lakhs, the total requirements thus being Rs. 106 lakhs.

(ii) *Synthetic Fibres*

The first cellulosic man-made fibre production in India commenced in 1950 and synthetic ibre in 1962, the total production in 1971 going upto 1,32,300 tonnes. The Task Force on ynthetic fibre has estimated the production of the synthetic fibres in 1973-74 at 1,79,000 onnes and the requirement in 1978-79 at 2,75,000 tonnes. At present. the following items are produced in our country: normal type of viscose staple fibre, filament yarn and tyre cord, acetate rayon staple fibre and filament yarn, Nylon-6 staple fibre and filament yarn, polyester staple fibre and filament yarn. Production of acrylic staple fibre has commenced only on a pilot plant scale.

The sub-group has identified RDD projects in both the fields of cellulosic fibres and synthetic fibres and their conversion into consumer fabrics. The objects are to bring about economy in production, improving aesthetic appeal and diversification of products and thus cater to consumer preference. The cellulosic fibre plants which were originally set up in the country were small in size and were slowly expanded step by step to an economic and viable stage. They are now in a position to go in for the continuous process as against the original batch process with which they commenced production. They can also economise in consumption of sulphur which is an imported commodity thus saving valuable foreign exchange. This is the theme of one of the projects.

Another project proposes improvement in the properties of regular rayon staple and to develop the technology for the manufacture of different types of high performance speciality cellulosic fibres.

At present, many of the factories import their requirements of pulp for manufacture of filament yarn. Hence, improvement of the existing dissolving grade pulp from hardwoods available in India to suit the above requirements is of vital importance.

Regarding synthetic fibres, the sub-group has suggested projects to evolve suitable blend composition of synthetic and natural fibres to give optimum properties and a durable fabric at an economical cost. To find out new outlets for man-made fibres and wastes, projects to develop and perfect non-wovens techniques have also been identified. Endeavours are to be made to improve production of synthetic yarn for tyre cords to overcome the weaknesses present in the fibres now being used.

A spcial feature of the above projects is that quite a few of them are to be implemented by private sector RDD establishments. The only other institution in the picture is SASMIRA which is a cooperative research association obtaining 50 per cent of its funds from the CSIR The sub-group had suggested a few more projects for manufacture of synthetic fibres like Nylon-4, Polypropylene, their monomers etc. and projects allied to the manufacture of the monomers.

(iii) *Wool*

The working group on woollen fabrics of the Planning Commission Task Force on Textiles has indicated the availability of woollen worsted fabrics for domestic consumption at the end of the Fourth Plan at 20 million metres and that to be made available at the end of the 5th plan as 50 million metres. The Group has also estimated the import requirements of wool and rags at Rs. 102 crores, and fixed the export targets of various woollen items at Rs. 125

crores, visualising decline in export of indigenous raw wool and growth in export of woollen carpets. It has envisaged that Indian Woollen industry can develop into a truly export oriented industry.

This sub-group has identified 14 projects on better utilisation of wool produced in the country. Proper evaluation of Indian wools would be the basic starting point for the above objective. Having evaluated the various wools, diversifying our production to the end-products best suited, would be the next step. As elsewhere, dyeing and improvements in finishing are also necessary. Development of auxiliary products is the aim of another project. Though a total expenditure of Rs. 287.35 lakhs has been proposed for these projects, the pilot plant equipment commonly needed for all the projects and costing about Rs. 89 lakhs would be in addition. The industry is, however, willing to bear the burden of expenditure to the tune of Rs. 136 lakhs, for land and new buildings etc. for the Wool Research Association (WRA) which is to come up at Thana near Bombay. Regarding rearing and breeding of sheep for wool, the ICAR has a Central Sheep and Wool Research Institute at Avikanagar, Rajasthan and projects on evaluation of a suitable design for machinery for shearing and grading of wool are being taken care of by this institution.

(iv) *Jute Products/Process Technology and Machinery Development*

The position confronting the Indian Jute Industry exports is bleaker than what it had been in the sixties. There are indications that polypropylenes can compete even in the Indian domestic market. In order to cope with the prospects of techno-economic obsolence, the sub-group has suggested RDD projects to maintain the tempo on export fronts as well as meet the domestic challenge. The sub-group has borne in mind the following important tasks such as making jute goods much cheaper than they are today, finding new uses for existing jute goods, making new products from jute which will be suitable for new uses, eliminating undesirable properties in jute, and making an all-out effort to improve and maintain quality..

The suggested RDD projects aim at standardisation, evaluation and upgrading of the raw jute fibre, adoption of novel forms of spinning like twistless and rotor spinning as in the case of cotton textiles, improving the aesthetic appeal by appropriate dyeing and finishing and improving the light fastness, blending with other fibres etc. Better utilisation of hard barky jute by microbial softening would effect economy; studying the possibilities of alternative emulsions as batching oils which would not contaminate the contents etc., is necessary to meet the demands of discriminate overseas consumers.

The projects identified above are to be mainly executed by the two research institution IJIRA and JTRL under the CSIR and ICAR respectively. IJIRA is a cooperative research association of the Jute Industry getting 50 per cent financial grants from CSIR.

(v) *Agricultural and Genetic Research on Jute*

One of the many reasons why the premier position occupied by jute as a packing medium is actually dwindling down is the cost of raw jute production. Therefore, while preparing the RDD projects, this sub-group had considered that the national average is to be improved to 20 q/ha or above, even if loss of crop due to natural calamity is taken into account and to stabilise the standard of quality of fibre in each ecological unit. The necessity for immediate RDD work on other similar fibre crops like mesta, hemp and ramie for diverse uses was also felt and projects formulated accordingly. Schemes for mutation, hybridisation and selection to ieve stabilised levels of yield and quality of fibre and correcting genetically the disease ceptibility have been proposed. Study of inheritance of qualitative and quantitative trends the breeds, quality parameters of fibres and technological basis of yield are necessary to noeuvre the problem of genetic improvement. Study of soils and the jute fibres resulting m them has been suggested. Biological control of pests, especially mealy bugs of North ar, screening the resistance for spiral borer, top sheet borer of sun-hemp etc. are to be taken Improving the conditions of retting and evolving machines of ribboner and decorticator e been suggested. Studies on high yielding and early maturing crops would help to switch r from mono-cropping to multiple cropping.

A number of agencies like JARI, IJIRA, JTRL and educational institutions like Burdwan iversity, Kalyani University and Assam Agricultural University will participate in the work ich is to be coordinated by JARI.

The total RDD projects identified by the Textile Group come to 108 worth Rs. 12.71 crores, which Rs. 1.58 crores is by way of foreign exchange component. The employment potential eated, is estimated at 561 persons per year over a period of 5 years.

FOOD

Because of its impact on the common man, food has attracted great attention in the anning process from various agencies. Moreover, it is closely linked with agriculture and nnot be entirely considered in isolation. The agricultural programmes have already been scussed under the Panel on Agriculture. The Planning Commission Steering Group on Agrilture, Irrigation and Allied Sectors has identified in great detail the RDD requirements coming nder this area.

The group on Food set up sub-groups on Cereals, including their processing, inspection d storage, Milk & Dairy Products, Animal Husbandry, Fish Processing, Vegetables and Fruits, ils, Proteins and other Subsidiary Foods and Plantation Crops.

The projects identified by all these sub-groups were subjected to a review after the Steering roup report on agriculture and ICAR's 5th Plan Schemes were known. The list thus emerging also being reviewed further, so as to enable to the extent possible, the targets set out in the eering Group report to be reached.

(i) *Cereals—Processing, Inspection and Storage.*—While the major work of research on the igh yielding varieties of food grains has been taken care of by other agencies, this sub-group as confined itself to processing, inspection and storage and has suggested studies on wheat ocessing, evaluation of paddy of good milling quality, pulse processing, proper utilisation and pularisation of maize and millets and their nutritive aspects. The main emphasis of this suboup is on post-harvest technology, evolutions of improved types of large, medium and nall storage structures to suit the rural environment and their popularisation. The expertise f the Indian Grain Storage Institute and other structural engineering institutions are proposed be utilised for this purpose. The other projects are mainly to be undertaken by I.C.A.R.

(ii) *Milk and Dairy Products and Animal Husbandry.*—The main problem of increasing the ield of milk and hence its availability to the masses is taken care of by the cross breeding of igh yielding animals by I.C.A.R. in their programmes. The sub-group on Milk and Dairy roducts has confined itself to studies for recovery of by-products like whey, ghee, residues tc., and standardisation of the technique of production of bacterial rennet on a pilot plant scale, storage studies on sterilised milk and so on. On the animal husbandry side, high dressing yield of sheep, goats etc., improving meat processing and slaughter house operatio poultry breeding and such other items have been proposed. The above projects are to undertaken by the National Dairy Research Institute at Karnal and the Indian Veterin Research Institute at Izzatnagar.

(iii) *Fish Processing.*—This sub-group has suggested strengthening of the various divisions the Central Institute of Fisheries Technology and the projects are to be undertaken by I.C.A.

(iv) *Oils, Proteins and other Subsidiary Foods.*—Attention is focussed to increase groundn cultivation, introduction of sunflower in selected areas, maximal use of the same for dieta formulations, development of new strains of sesame, upgrading of oil cakes for animal nutriti etc. All these projects are proposed for being implemented by I.C.A.R.

(v) *Plantation Crops.*—A number of projects for improving exports and bringing up econon in production of tea, coffee, cocoa, spices, food flavours etc. have been proposed. One of t favourable trends in research in this field is the emergence and establishment in 1972 of t Central Plantation Crops Research Institute under the I.C.A.R. in Kasargod, Kerala.

There are only two research institutions working on tea plantations, one at Tocklai Assam and the other at Anamalai in Tamil Nadu. Work on coffee is to be undertaken by t Central Coffee Research Institute at Balehonnur, Mysore. All the institutions would take t assistance of CFTRI, wherever necessary. The finances for research on tea, coffee cardamo etc. are to be provided for from the respective commodity Boards from out of the Cess Fun and hence they are treated as non-plan expenditure.

The total RDD projects identified by this group come to 51 worth Rs. 6.91 crores of whi Rs. 0.29 crores is by way of foreign exchange component.

SUGAR

Even though sugar forms a part of food, as the production of sugar covers a wi variety of interests and involves a number of problems, a separate group for sugar was forme This was further subdivided into sub-groups like (i) Sugarcane and Sugarcane Developme (ii) Sugarcane Machinery (iii) Sugarcane Technology & Processing and (iv) By-product Utilis tion. In addition to the expertise of the members of the Group, about 500 and odd institutio were contacted to gather as much information on the subject as possible.

The Planning Commission Steering Group on Agriculture has estimated the *per capi* sugar consumption at 8.68 Kgs, and targeted 170 m. tonnes of sugarcane production fro the projected level of 138 m. tonnes in 1973-74. The above targets also take into account t increase planned in production of sugarbeet from the current level of 30,000 tonnes to 3 milli tonnes. In order to achieve these levels of production, the Group, while not on endorsing ICAR's projects on sugarcane development, has also identified some problems whi would be taken up at the several existing Universities/Research Stations/Coordinated Cent without any additional financial input. These projects are, ratoon management, seed produ tion technology, autumn planting and companion cropping, controlling of flowering throu chemicals, response of Phosphate & Potash on ratoon crops, improvement of cane quality und low temperature conditions, improving efficiency of nitrogenous fertilizers, drought and wat

ging conditions, improving efficiency of water utilisation, weed control measures with mini-
m tillage epidemiology of wilt and red rot diseases etc.

The group has also proposed a few additional projects like facilities for increasing the
ff supplying capacity at the Coimbatore Institute, artificial ripening of cane, steps on effec-
e control of sugarcane borers etc.

At present, National Sugar Institute at Kanpur is the only institute concerned with Sugar
chnology. Due to the future trend of further expansion of the industry in the Deccan and
uth India and also due to the great difference in agro-climatic and soil conditions, the Group
s felt that the interest of the industry will be more effectively served by having two more
stitutions, one each at Poona and Madras. Further, the proximity of advisory and extension
vices would be more effective. The group has also suggested two Regional Research Cells
carrying out research on regional problems, to be attached to each of the three Institutes at a
al estimated cost of Rs. 2.5 crores. [to be located in Bihar, Punjab, Haryana, Maharashtra,
ysore and Andhra Pradesh.]

However, in line with the thinking enunciated in the stategy to the NCST Plan
begin with, only one new institute may be started in the present plan, the location of which
ay be decided upon in due course. Hence, funds have been sought for only for one more
stitute and four regional cells.

It has been found that it is very necessary and urgent to enlarge the scope and capabilities
the National Sugar Institute to satisfactorily undertake and discharge its various responsibi-
ies. Hence, a development plan has been recommended for the institute at a cost of Rs. 2.5
ores and several additional problems covered in the different projects allocated to it.

The next important recommendation of the group is the establishment of a design and
velopment centre for sugar machinery.

With the development of sugar machinery manufacture in the country and development of
wer designs of equipment in different parts of the world, the group has considered that there
adequate engineering and designing talent in the country and knowledge of the requirement
sugar processing. Therefore, it has suggested that a new Design and Development Centre
r sugar machinery should be started. This organisation which may be called "Sugar Machi-
ry Development Organisation (SUMADO)" should be located at Poona, where the facilities
the National Chemical Laboratory and the Mechanical Engineering Research & Develop-
ent Organisation are available, and also because of the proximity of two sugar machinery
anufacturers. This Organisation will begin with the collection of data, development of designs
d testing of new equipment. Immediately, the SUMADO will undertake studies on investiga-
ns on ancillary equipment to the milling plant, milling and diffusion, trayless clarifier,
ulticell floatation clarifier, etc., where necessary, in collaboration with the N.S.I. Kanpur, and
y other sugar machinery manufacturer. The estimated expenditure for this organisation is
. 2.5 crores.

With regard to projects concerning research in sugar technology and processing, the group
line with the Steering Group recommendations, has suggested trials to perfect the system

of payment of cane price on quality basis. Other projects suggested include improvement in clarification process, studies on exhaustibility of molasses, bulk storage and handling of s etc.

The sub-group on By-product Utilisation has suggested studies for manufacture of furt from bagasse, depithing of bagasse, utilisation of bagasse for paper pulp, particle board ma facture etc. These have been referred to the Panel on Recycling of waste. Studies on the of starch syrups in breweries etc., have also been suggested.

The total RDD projects identified by this group come to 32 worth Rs. 15.86 crores which Rs. 3.49 crores is by way of foreign exchange. The employment potential created wo be 167 persons per year over a period of 5 years.

LEATHER

Footwear and leather goods serve the common man's needs. These should have qual durability and price attraction whether for export or local consumption. RDD plays a la part in achieving these. The contribution of leather industry to India's exports, principally in form of semi-tanned leathers, stood at Rs. 175 crores, in 1972-73.

The RDD efforts in the field of leather in the country has succeeded considerably in chang the face of the industry which is expected to turn over large exports of finished leather, footw leather manufactures etc. The Central Leather Research Institute, Madras, of the CSIR has b the pioneering institution in this field. The group on leather has, therefore, felt that all projects that it has identified, may be carried out by this institute. The group has also indica the requirements for building up infrastructure in the institute and fields where the exist infrastructure may have to be expanded or restructured to meet the plan requirements. Wit the industry, there are three distinguishable sub-groups, *i.e.* (i) tanning and finishing leather (ii) manufacture of footwear and (iii) manufacture of other leather goods. Much rural tanning is carried out under unscientific and uneconomic conditions thereby rendering value of the tanned leathers generally low. Again, the use of good quality hides for footw and other leather goods lacking both in quality and variety reduces the value of these produ marketed and marketable in the rural areas to about only 40 to 50 per cent of their real mar value. Thus, considerable waste of product value in the leather and leather products turn out in rural India can be saved almost in full, only through a massive programme of extens of RDD knowledge suitable for absorption by the rural artisans combined with an equally la scale programme of training in tanning and tooling of leather at the village level.

The projects identified range from improving the quality and better utilisation of the r hides and skins, research into the various aspects of the vegetable tanning agents and utilisati of their waste, synthetic tanning materials and resins to improving and imparting desira qualities of leather etc. Tanning and finishing of leathers and footwear research and develo ment have been given priority.

The group has also suggested the establishment of leather goods development cum produ tion centre, industrial and technical information centre and regular extension services to ba up all the above RDD Projects.

The total RDD projects identified by this group come to 39 worth Rs. 2.54 crores which Rs. 0.43 crores is by way of foreign exchange component. The employment potential th would be created is estimated at about 200 persons over a period of 5 years.

SALT

In this field we are now able to meet our requirement, both domestic and industrial, and o make marginal export. Our total production in 1972 is likely to be 6 million tonnes. How- er, there is a lot of scope for further improvement of the industry which is under-utilised, so at it could also bring home valuable foreign exchange.

The group has identified more than 10 projects. Some of these like fortification of salts, covery of bromine etc., have been taken care of by the Chemical Industry panel. Some the other programmes which have been identified relate to mechanical harvesting of salt, soil abilisation of the salt farms, washing of raw salt and improving the potassium chloride content mixed salt of potassium chloride and magnesium sulphate by phase rule chemistry studies. echanisation of salt works is proposed to be done in stages, considering the socio-economic nditions prevailing in the locality.

As our future demand of salt is mostly for chemical industries and export, the large sized lt works will need complete mechanisation of the operations, of harvesting, washing, destac- ng, filling, loading, etc. It will then be possible to reduce the cost of production, improve ality to suit the industry and increase productivity. Hence, the project aims at complete echanisation of the future large sized salt works and partial mechanisation of the existing lt works in view of the heavy capital expenditure involved in complete mechanisation.

The total RDD projects identified by this group come to 5 worth Rs. 0.15 crores of which s. 0.02 crores is by way of foreign exchange component. The employment potential created estimated at 81 persons per year over a period of 5 years.

CAMERA & PHOTOGRAPHIC CHEMICALS

The Group on Camera and Photographic Chemicals comprised two sub-groups, one on amera and the other on Films and Photographic Chemicals.

The sub-group on Films and Photographic Chemicals has identified 16 RDD projects. It as proposed that, as the RDD facilities at the only premier institution for this purpose, at industan Photo Films Manufacturing Company Ltd. (HPF) Ootacamund is a new Photo oducts Development Laboratory may be set up, preferably under the aegis of HPF at Ooty in the alternative under C. S. I. R., for implementation of these projects. The projects e mainly of two kinds, one for films and their coating, emulsion formations, improvement the quality of the above etc., and the other for development of synthetic, analytical, organic d other photographic chemicals. The Camera Sub-Group has not yet submitted its report.

The total RDD projects identified by this group come to 16 worth Rs. 3.91 crores of which s. 1.46 crores is by way of foreign exchange component. The employment potential created is timated at 243 persons per year over a period of 5 years.

TOBACCO

In view of the fact that Tobacco and Tobacco products are also greatly used by the poorer asses, a group was formed with sub-groups on the Health Hazards, Bidi, Hookka etc., machi- ry development for these products and agricultural aspects of tobacco. The reports of ese groups are still under finalisation.

The Financial outlays Recommended by the Various groups are as under:—

S. No.	Group	Financial outlay Rs. in lakh
1	Textiles, including Synthetic Fibres, Cotton Textiles, Jute, Wool etc.	1270.90
2	Food including Cereals, Milk and Dairy products & Animals Husbandry, Fish Processing Vegetables & Fruits, Oils & Proteins, Tea , Coffee and Spices etc.	690.05
3	Sugar	1585.83
4	Leather	254.12
5	Salt	14.60
6	Photographic Films & Related Chemicals	391.00
	Total	4206.50

The details of the various projects are given below :—

roject ndex. No.	Title of the Project	Financial outlay
14G Textiles		(Rs. in lakh)
	Synthetic Fibres	
$_{14}G_1A_1P_1$	Production economy in viscose process	3.48
2	Improvement in quality of viscose rayonstaple and production of high performance speciality cellulosic fibres	15.60
3	Improvement in quality of existing dissolving grade pulp for continuous filament yarn	4.50
4	Development of auxiliaries for viscose industry	2.03
5	Development of apparel fabrics	10.00
6	Development of industrial fabrics	12.00
7	Pilling prevention from synthetic man made fibres and their blends	3.33
8	Development of non-wovens	5.00
9	Development of acrylic fibres	21.82
10	Production of synthetic yarn for tyres	14.80
11	Polyester fibre for tyre cord	N. A.
12	Bulked and stretched yarns	3.33
13	Development of metallic and metallised yarns	3.00
14	Production of elastomeric fibres.	15.33
15	Polyester chips production using different catalysts	3.65
16	Continuous polymerisation and spinning of synthetic fibres	18.77
17	Graft copolymer fibres	4.77
18	Carbon fibre	7.00
19	Bicomponent fibres of nylon, acrylic polyester and polypropylene.	10.00
20	PVC Fibre	2.00
21	Nylon-4	8.00
22	Fibre webs	5.00
23	Copolyesters (Cacron 62, Vycrone, etc.)	N. A.
24	Polyphenylene oxadiazole	N. A.
25	Modified polypropylene fibres	N. A.
	Sub Total	174.21
	Jute Process/Products Technology & Machinery Development	
$S_{14}G_1A_2P_1$	Grading of Raw Jute fibre	18.00
2	Jute fibre preparation and upgrading	29.90
3	Twistless spinning of Jute	17.20
4	Rector spinning of jute	14.50
5	Development of core/composite spinning	12.88
6	Alternative lubricants for jute spinning	7.60
7	Development of dyeing of jute decorative fabrics	12.38
8	Finishing treatments on jute decorative fabrics	12.75
9	Evaluation of fibre quality	8.46
10	Microbial softening of hard barky jute for its better utilisation	11.00
11	Improvement of light fastness of bleached jute	20.00
12	Effect of carding parameters	22.40
13	Reduction of drawing passages and development of autoleveller	27.50
14	Investigation of suitability of potspinning	14.60
15	Blending of jute with other fibres	15.00

1	2	3
$S_{14}G_1A_2P_{16}$	Knitting with jute yarn	13.41
17	Preparation of non-woven fabric from jute fibre	24.08
18	Fire retardancy of jute fabrics	16.62
19	Development of on-line testing and control instrumentation	12.48
20	Preparation of improved types of emulsions for jute processing	7.05
21	Modification of conventional jute looms for weaving double fabric for sack making	9.00
22	Control equipment for size preparation	10.08
23	Development of methodology and equipment for testing mill accessories	21.06
	Sub-Total	357.95
	Cotton Textiles & Blends	
$S_{14}G_1A_3P_1$	Improving ginning practices.	5.20
2	Studies of fibre friction and cohesiveness and rupture of fibre assemblies in relation to processing performance in cotton spinning and yarn properties	2.20
3	Systematic evaluation of Indian cottons.	3.75
4	Development of testing instruments and process control systems for the textile industry	9.30
5	Use of Indian cottons (a) on blends with man-made fibres and (b) for fine and superfine mixings	3.35
6	The effect of heating and cooling synthetic fibres on structures and properties.	2.55
7	Development of unconventional methods for achieving fibre parallelisation and removal of fibre clustering	2.00
8	Methods to increase yarn production	13.45
9	Exploration of means and methods to improve fabric appearance	5.05
10	Improvements of weaving performance through better preparation of yarn and by modification to loom parts.	7.10
11	Conversion kit-continuous weft insertion weaving machine.	2.92
12	Warp Knitting of Spun yarn	23.70
13	Investigations on Preparatory wet processing of cotton and polyester/cotton fabrics.	10.90
14	Improving abration resistance of Resin treated cotton fabrics.	1.48
15	A study of the soiling of textiles and development of antisoiling and soil release finishes.	3.55
16	Exploration of the possibility of improving strength and abrasion resistance of resin finished fabrics.	4.50
17	Colour matching by computer	6.90
18	Attempts to impart self-smoothing properties of silk	0.70
19	Study of swelling characteristics of cellulose	6.30
20	Investigations for economising, reusing and purification of processed water and effluents from textile mills	1.65
21	An investigation of the Vapour phase treatment of cotton and cotton/polyester blend fabrics wih a view to modify chemically the surface of the fabric in order to impart desirable properties to cotton.	3.03
22	Setting up design centres for textile industry (i) for machinery building, library etc. to be established at SITRA, BTRA & ATIRA (ii) for a pool to finance fabrication of prototypes	486.00 25.00
23	A study of influences of yarn quality and geometry of cloth structure on the physical behaviour of woven and knitted fabrics	4.25
24	Development of suitable flame retardant finishes for cotton and cotton blends	6.40
25	The effect of atmospheric conditions during drafting, on drafting force, efficiency and product quality.	2.05
26	Fabrication of a machine for continuous production of bulk yarn by twist and back-twist method.	2.21
27	Structure and properties of open-end yarn.	5.00
28	The cost of yarn and cloth faults in modern spinning and weaving mills.	3.76
29	Effect of heat and moisture on the visco-elastic properties of cotton fibres and yarns.	0.95
30	Technical Service Centre for powerlooms.	106.00
31	Investigations on the chemical modification of cotton with a view to impart better dyeing and printing characteristics.	2.54

(1)	(2)	(3)
32	A study of cotton textile materials treated with metallic and elastomeric filler compounds.	1.45
33	Exploratory Research on the introduction of boron compounds into cotton cellulose in an attempt to obtain new and useful properties of cotton.	1.35
34	Novel spinning process	18.13
35	Special methods for the production of difficulty spinnable fibres.	16.24
	Sub-Total	800.82
	Genetic & Agricultural Research on Jute :	
$G_1A_4P_1$	Collection, evaluation and maintenance of germplasm of jute and allied fibres.	20.68
2	Introduction of mutation in jute and evaluation at different agro-elimatic zones.	11.37
3	Selection and breeding for different purposes.	24.69
4	Genetical studies in jute.	21.29
5	Evaluation of Criteria for selection for high yield in jute.	33.36
6	Study of soil in relation to fibre properties.	14.23
7	Biological control of jute pest.	6.88
8	Fibre processing by mechanical means and acceptability test of resulting fibre.	21.75
9	Retting studies aiming at uniform quality of fibre.	15.08
10	Evaluation of Hibiscus Sabdriffa type with a duration around 190 days, having yield level of H. S. 4288 and AMV-1.	9.12
11	Breeding for resistance to Phytopthrra Parasiliaca form Sabdariffil causing foot and stem not in Hibiscus Sabdriffa.	5.74
12	Control of mealy bug for North Bihar.	5.52
13	Screening for Fleshy Calyx in Hi Sadariffa.	10.20
14	Screening for resistance to Spiral Horer in Hibiscus Cannabinus type.	4.48
15	Screening for glandless type in Hibiscus Cannabinus.	5.37
16	Indection of mutation in sunhemp	1.95
17	Biological control of top shoot borar of Sunhemp	4.25
18	Utilisation of hybrid vigour in ramie	3.21
19	Induction of mutation for lower denier in ramie	2.71
	Sub-Total	221.88
	Wool	
$G_1A_5P_1$	Evaluation of Indian wools	57.20
2	Improvement in technology and end-products in Indian wool textile industry.	59.09
3	Improvements in dyeing of wool and its blends	24.46
4	Improvements in finishing of wool	14.02
5	Development of polymers for application to wool	9.90
6	Development of raw apparal and industrial fabrics	25.00
7	Machinery developments for wool	26.40
8	Development of auxiliary products.	5.00
9	Sizing of single worsted yarns	5.00
10	Testing and certification of greasy wool	21.26
11	Design and development of an indigenous shearing machine.	4.00
12	Wool Grading : Studies on (a) the inter-relationship of fibre parameters among samples drawn from individual fleeces, mixed fleeces and their graded lots of wool of different geographical regions, and (b) Variations in wool quality between fleeces from sheep's back and the graded lots prepared from flocks of the same breed.	27.00
13	Studies on the effect of temperature humidity and light on the quality of wool during storage.	5.00
14	To evolve standard wool pack for storage and transporting raw-wools.	4.00
15	Infra-structure facilities	89.00
	Sub-Total	376.35

1	2	3
	S₁₄G₂ FOOD	
	Cereals their Processing Storage etc.	
$S_{14}G_2A_1P_1$	Studies on wheat processing, conditioning, milling and baking	15.
2	Evaluation of paddy varieties with good milling qualities	15.
3	Research on pulse processing and improvement of existing pulse processing machinery	15.0
4	Research on proper utilisation of maize and development of animal feed out of maize	15.0
5	Research on processing of millets and its nutritional aspects	10.
6	Development of non-pesticidal methods for control of pests	10.0
$S_{14}G_2P_7$	Research design and development of improved types of stores structures	80.
8	*Popularisation of improved storage structure training and demonstration facilities in scientific storage.	80.0
	Sub-Total	240.0
	Milk and Dairy Products and Animal husbandry	
$S_{14}G_2A_2P_1$	Standardisation of the techniques for recovery of proteins and other constituents from dairy by-products such as whey, ghee residues etc.	1.9
2	Standardisation of the techniques for the production of acceptable quality of bacterial rennet on a pilot plant scale.	2.8
3	Chemical, bacteriological & toxicological investigations of Milk & Milk Products	2.
4	Sterilised Milk : storage studies on sterilised milk prepared in large plants	1.
5	Technology for development of higher dressing yield for sheep, goats, pigs and buffaloes	17.0
6	Technology for improved meat processing and slaughter house operation	5.0
7	Extensive analysis of the poultry food ingredients and determing their nutritional contents from season to season	5.0
8	Poultry Breeding	20.0
9	Poultry Housing and Research on the physiological behaviour of birds under different climatic conditions and under different types of housing with a view to determing optimum conditions of housing and environment.	4.0
10	Processing of built-up litter manure from poultry farming for livestock feeding	2.0
	Sub-Total	61.0
	Fish Processing	
$B_{14}G_2A_3P_1$	Investigations into the problems connected with handling, processing, preservation, on-board deep sea fishing vassels; Trawlers, purse seiners and gill netters.	N.A
2	Investigations into the problems connected with handling processing etc. with emphasis on freezing detericration in frozen storage.	N.A
3	Investigations into the problems connected with handling, processing etc. and transport of fish on landing at the wharf, at the landing centre in fishing villages.	N.A
4	Investigations into the problems connected with fish filletting, design of suitable gutting tables, cleaning, packing machinery.	N.A
5	Improvements in sun-drying methods of fish and fishery products by the introduction of efficient cheap solar dryers.	N.A
6	Investigations into the problems connected with fish freezing, storage and distribution of frozen small fish, both for external and internal markets.	N.A
*7	Investigations into the problems connected with fish canning technology	N.A
*8	Investigations on designing suitable automatic smoke kilns and intensification of smoking of suitable varieties of fish which have an export demand.	N.A
9	Research in irradiation, pasteurization of fish and fishery products. Steps to install suitable gamma cells at the important fishing centres.	N.A
	Sub-Total	218.00

P_7 and P_8 are also identified by the Panel on Housing and Urbanisation—Planning Group 7—Rura Housing and Development.

*The total financial outlay is Rs. 218 lakhs for all the projects taken together of which Rs. 75 lakhs i earmarked for Land & Building. These are to be met by the ICAR from its Fifth Five Year Plan.

1	2	3
	Vegetable and Fruits	
${}_4G_2A_4P_1$	Introduction of new packaging materials and evaluation of suitable designs for different types of packaging for vegetables and fruits.	1.00
	Sub-Total . . .	1.00
	Oils, Protein & other Subsidiary Foods	
${}_{14}G_2A_5P_1$	Increased attention to groundnut cultivation; Varietal selection of groundnuts for maximum crops and oil yield.	N.A.
2	Introduction of sunflower in areas where rainfall is not assured or irrigation facilities are limited or soil conditions are unfavourable for groundnut cultivation.	N.A.
3	Research and extensive work for the development of new strains of sesame of the non-shattering and high yielding variety.	N.A.
4	Research on the maximal use of sunflower for incorporation in dietery formulation	N.A.
G_2A_5P 5	Research programmes of improvement and innovation in the oil extraction industry aimed at higher recoveries of oil and edible quality oil cakes suitable for use in human nutrition.	N.A.
6	Research on upgrading of cakes for use in animal nutritional products both internally and for export (groundnut, mustard, neem etc.)	N.A.
7	Research on the improvement of cocoa-butter as well as high value confectionery fats from special Indian fat sources for export.	N.A.
8	Preparation of high quality protein isolhates from groundnut for use in most extenders and meat substitutes.	N.A.
	Sub-Total . .	100.00**
	Plantation Crops	
	Tea :	
$S_{14}G_2A_6P_1$	Improvement of machinery employed in controlled withering, fermenting and evolving a continuous process for black tea manufacture.	15.00
2	Development of methodology and instrumentation for in-plant quality control and for quality grading.	5.00
3	Study of the bio-chemical changes occuring during wet processing and fermentation and of the physico-chemical changes during roasting and of their influence on brewcharacteristics.	3.00
4	Survey of tea and coffee products for monitoring pesticidal residues	6.00
	Coffee :	
P_5	Improvement in the machinery and process in the manufacturing of coffee including accelerated removal of mucilage and pulp and control of ferentation.	3.00
6	Development of technology for production of decaffeinated coffee i	1.00
	Food Flavouss	
P_7	Survey of indigenous plants for aromatic principles	2.00
8	Basic work on the chemistry of flavour components, their biosynthesis, natural flavour protectants, etc.	2.00
	Cocoa :	
P_9	Development of process technology for cocoa beans including optimisation of roasting conditions production of cocoa powder and butter. Improvements in analytical methods and evolving standards for these.	2.00
10	Standardisation of harvesting of cocoa and pretreatment procedure including mechanical or enzymic depulping, optimization of fermentation condition etc. Comprehensive survey on varietal suitability for cultivation with respect to yield and desired aroma, manurial regimen, pest control etc.	2.00
11	Investigation on varietal regional and harvesting factors affecting quality attributes of processed product in the case of ginger, cardamom, turmeric etc.	5.00
	Walnuts :	
12	Standarisation of process technology and storage of in-wheel walnuts as well as kernels, development of suitable machinery for shelling of walnuts.	1.00

**An outlay of Rs, 100 lakhs is estimated for all the projects taken together.

1	2	3
	Spices :	
P13	Pharmacological and physiological investigation on spices and spice constituents. Investigation on the chemistry of active constituents of flavour including their stability, methods of analysis etc.	10.
14	Standardisation of process optima and equipment for grinding of spices with minimum loss of flavour and pungency and study of chemical reactions occuring during storage.	2.
15	Standardisation of specialised techniques sueh as bleaching of ginger, cardamom, curing of cinnamom bark, etc.	1.
16	Programmes for optimisation of dry-conditioning and pre-treatment, development of mechanical process for drying, removal of staik, husk, etc.	10.
	Sub-Total	70.0
	Sugar :	
S14G3P1	Facilities for increasing fluff supplying capacity of the Sugercane Breeding Institute, Coimbatore.	2.
2	Studies on the artificial ripening of sugarcane by making use of chemicals . . .	2.
3	Studies on improving the quality of sugarcane under different soil and climatic conditions	2.
4	Studies on biological control on Sugarcane Borers and Scale Insects	15.
5	Studies on the role of Soil Micro-Flora on Sugarcane soils and also effect of agro-chemicals.	6.0
6	Survey of agronomic and plant protetcion practices	10.
7	Review of the recommendation on sugarcane research	3.
8	Starting a course at the Indian Institute of Sugarcane Research, Lucknow for training Agricultural graduates in Sugarcane agronomy.	15.
9	Trials to perfect the system of payment of cane price on quality basis. . . .	10.
10	Studies on the Demineralisation of sugar-cane use by ion-exchange process. . . .	
11	Pilot Plant trials for the manufacture of lactic acid from waste molasses	
12	Studies on the manufacture of the yeast by using sugarcane molasses. . ..	250.
13	Pilot plant trials for the extraction and purification of sugarcane wax, from press-mud.	
14	Pilot plant trials for the production of oxalic acid from molasses.	
15	Funds for the establishment of regional research institution..	200.
16	Funds for the establishment of one new regional centre and 4 regional reseach cells. .	170.
17	Funds for the establishment of a new organisation known as Sugar Machinery Development Organisation (SUMADO) at Poona.	250.0
18	Studies on the composition of sugarcane juices in various parts of the country and their clarification.	12.0
19	Development of natural and synthetic floculating agents..	8.4
20	Identification and removal of colour causing compounds in sugar house products. .	7.6
21	Adoption of Phosphitation Process for the manufacture of white sugar. . . .	2.7
22	Studies on the exhaustibility of molasses.	9.7
23	Investigations into the existing and ancillary equipment of the milling plant with a view to simplifying or improving the preparation of cane and extraction of sugar.	9.0
24	(a) Studies on Milling and diffusion of sugarcane	
	(b) Development of a Trayless Clarifier and Melt Clarifier similar to Saeranin's Multi-cell Flotation Clarifier.	
	(c) To design continuous vacuum pan with necessary controls and continuous water cooled crysttaliser.	5.0
	(d) To develop a resistance heating arrangement for Massecuites	
25	Studies on the bulk storage and bulk handling of sugar. . . .	1.1
26	Pilot plant studies for the manufacture of Furfural from bagasse. . . .	9.2
27	Studies on the depithing of bagasse, its economics and technology	3.7
28	Studies on the utilisation of whole bagasse, depithed bagasse, residue left after water digestion of bagasse and residue left after acid treatment of bagasse for the manufacture of pulp, paper and board.	8.5
29	Studies on the utilisation of pith for the manufacture of particle board . . .	0.9
30	Studies on the treatment of effluents and specify pollution limit. . . .	3.6
31	Studies on the use of starch syrups and starch sugars in breweries.	1.5
32	Studies on the use of storch syrups and starch sugar food products	1.5

1	2	3
33	*Provision of *ad-hoc* funds for conducting research and extension of research at unit level in larger public interest.	50.00
34	*Schemes for the development of Sugarcane	137.17
35	*Schemes for the development of sugar beet	55.56
36	*Funds for the Infrastructure facilities of the Indian Institute of Sugarcane Research, Lucknow.	110.00
37	*Funds for meeting the expenses of the staff of the Indian Institute of Sugarcane Research Lucknow.	161.26
38	*Funds for improving the Infrastructure facilities and staff requirement of the Sugarcane Breeding Institute, Coimbatore.	50.00
	Total . . .	1585.83

Leather

G_4P_1	Raw hides and skins — Development of better utilisation techniques	4.70
2	Microbiological problems relating to leather and allied industries	1.02
3	Utilisation of collagen wastes as biomaterials in surgery	0.46
4	Investigations on the methods for profitable utilisation of blood from slaughter houses	0.30
5	Characterisation and treatment of tannery wastes	0.54
6	Utilisation of indigenous tan materials in place of imported wattle extracts . . .	0.55
7	**Part I.** Introduction, acclimatization and utilisation of Canaigre (Rumex hymenosopalus) as a root tanning material in India	
	Part II Studies on tanning-bearing plants with a view to increase tanning production in India	0.97
8	Synthetic Tanning materials and resins	0.49
9	Application of di or poly basic acids to impart in-built lubrication to leathers . .	0.29
10	Inorganic polymeric products for preservation and other qualities of leather . .	0.59
11	Oils, waxes and their products for use in leather, footwear and leather goods industries	2.75
12	Tanning and finishing of leathers	46.03
13	Simplified chrome tanning systems for adoption in Indian villages	0.10
14	Computation of physical parameters such as raw weight, pelt weight and area in different types of leathers	0.07
15	Biotechnological studies of pretanning agents and techniques	1.22
16	Sardine fish oil	0.13
17	Synthetic waxes and products/blends thereof for lubrication of leather	0.29
18	Adhesive for modern footwear production	1.71
19	Leather dyeing and allied projects	2.77
20	Development and uses of vinyl polymers, polyurethanes and high melting polymers in leather manufacture.	3.96
21	Development of indigenous leather finishes to meet the international specifications of finished leathers for export.	1.20
22	Footwear Research-cum-Development Project	23.17
23	Development of technical competence and expertise for the design development and maintenance of tanning and footwear machineries.	12.95
24	Leather goods cum development cum production centre	23.53
25	Sheet materials from leather wastes	0.18
26	Studies on the biological properties of vertebrate and invertebrate collagen . . .	1.29
27	Development of polymeric materials for application to leather and the grafting of synthetic polymers on to hides, skins and leathers.	10.41
28	Biochemical studies on individual skin proteins with particular reference to the metabolism and structural change.	1.38
29	Biophysical studies on finished leathers with a view to improve their performance characteristics.	0.17
30	Fundamental study of the structure of mineral tanning complex in the leather and its relation to properties.	3.80

Already included in the ICAR'S Five Year Plan.

OTE: —In addition to the above projects on Leather, the group has identified 13 more projects of varying degree of priorities for which no financial allocation is required.

1	2	3
31	Fundamental studies with a view to modify the nature of mineral tanning complex and its reactivity with Collagen and impart stabilisation of cross lines.	1.66
32	Vegetable tannage Isolation of polyphenolases from bacterial and mold sources and studying the interaction of these polyphenolases with the phenolic non-tans of certain vegetable tanning materials.	1.7
33	Role of hydrolysable components of condensed tanning	0.7
34	Extension services	48.1
35	Central data bank of leather and leather products	0.9
36	Industrial and technical information centre for leather and allied fields . . .	29.4
37	Research programming coordination and evaluation	0.3
38	Testing service facilities for leather and allied product industries	0.
39	Infrastrucutre services and facilities	23.2
	TOTAL	254.1
Salt		
$S_{14}G_5P_1$	Washing of salt — Design and modifications that are desired in form during solar evaporation of brine.	3.
2	Mechanisation of salt works	2.3
3	Soil stabilisation in salt works for mechanical salt harvesting	6.
4	Phase rule chemistry of oceanic salt system examining the possibility of up-grading the potassium chloride content of mixed salt at 33°C.	1.
5	Research and Development to increase the yield of salt works	0.
	Sub-Total . . .	14.
CAMERA PHOTOGRAPHIC FILMS & RELATED/CHEMICALS		**Relate**
$S_{14}G_6A_1P_1$	Development of high speed coating technology	35.
2	Deveelopment of manufacturing technology of high speed panchromatic films. (Development of photo sensitive emulsion formulation only, since coating technology is covered by Project No. 1 above)	5.
3	Development of Manufacturing technology for graphic art film (Development of photosensitive emulsions only	4.
4	Development of manufacturing technology of integral Tipack colour films. (Emulsion formations only with necessary facilities).	35.
5	Industrial X-Ray films (Emulsion formulations only)	3.
6	Development of document copying products	28.
7	Dental films	15.
8	Personnel monitoring film	
9	Fluoroscopic films	4.
10	Improvement in quality of X-Ray films, Cine sound, Photographic paper (emulsion quality only).	3.
11	Processing equipment for X-Ray films	7.
12	Improvement in processing equipment of cine film-black & white and colour . .	7.
13	Studies on dye-bleach process	12.
14	Development of process for instant colour films	30.
	Chemicals	
$S_{14}G_6A_2P_1$	Development and synthesis of chemicals. (analytical, organic), synthesis and testing laboratory facilities.	90.
2	Polyester film base (film casting only)	35.
	Other facilities	
3	Building and other basic facilities including library	75.
	Sub-Total	391.

SECTOR—KHADI & VILLAGE INDUSTRIES

KHADI AND VILLAGE INDUSTRIES

The Planning Commission has recognised in its Approach to the Fifth Plan, that expanon of productive employment opportunities is crucial to accelerating growth and reducing nequality. Therefore, as rightly pointed out by the Khadi Commission in its 5th Plan proosals, rural industries including khadi will have to be accorded an important place in the conomic development of our country in view of its capacity to create in situ employment pportunity involving low capital investment. Therefore, application of improvements in techology, which has hitherto been conditioned by the needs of the large scale sector, should ow be directed to the rural sector. As the Khadi and Village Industries Commission has layed a pioneering role in the development of rural industries, its assistance was naturally ought. This Panel was divided into two main groups, Khadi and Village Industries. The rojects identified by these groups are accordingly delineated in the following paragraphs.

Khadi

The problems in the khadi industry are reported to be more in (i) preliminary preparation of cotton for spinning and (ii) weaving. Therefore, the group has identified programmes to vercome these problems.

There is great scope for development of muslin, woollen and silk khadi. Consequently, some projects like adapting the new model charkha for woollen khadi, as well as other projects similar to those for cotton khadi have been identified. The group has felt that establishment of a garment design and manufacturing centre for khadi is necessary. The estimated cost for this project is about Rs 64 lakhs. This project has been left out from our list as it does not strictly fall under RDD. However, the group has felt that extension work of this kind is very necessary to utilise the fruits of RDD work.

Village Industries

Programmes to improve the technology in a number of village industries such as edible oil, bee keeping, gobar gas plants, and increasing the utilisation of non-edible oil seeds, have been identified. The project on improvement in the performance of Indian honey-bee and its utility in increasing crop yields due to planned cross pollination assumes importance from the agricultural productivity point of view. Cowdung, which is a valuable manure, is used as a fuel in our villages. Projects on gobar gas have been identified which would utilise both the fuel and manure components of cowdung. Devising materials of construction, which are within the means of the villagers, is to be investigated. As ICAR has also been engaged in this area of work, it should be associated with this project. Another similiar project is the utilisation of human excreta. Yet another project proposes to increase the utilisation of non-edible oil seeds by removing some of the technical difficulties in their efficient processing. The process of extraction of the non-edible oils needs to be standardised. Projects on improving efficiency of oil processing at the village level, development of jacquard boards and electrical insulation paper by the handmade paper industry, village pottery, cottage matches,lime, palm gur, processing of cereals, pulses, cane and bamboo have also been identified.

A central laboratory with all modern facilities is felt necessary to resolve technical problems pertaining to the village industries The Group has, therefore, suggested that the existing laboratory at Wardha should be upgraded and fully equipped, which involves an expenditure of Rs. 1 crore.

The Silk Industry and Coir Industry occupy an important place in the matter of provisio of gainful employment to people in the lowest strata and living in the backward regions o the country. In fact, the employment potential of the silk industry is said to be more tha the total of the khadi and village industries put together. The respective boards of thes industries have proposed some projects for the development of these industries whic have been included in this panel. In addition another group has identifie projects for integrated development of rural buildings, including research on rural constructio materials, village planning, markets for groups of villages, roads, water supply, sanitation etc The large scale association of academic institutes for intensive application of science an technology for integrated rural development, extensively covering various regions of the countr is envisaged. This would involve promoting several interdisciplinary groups which coul integrate with the rural milieu for disseminating science and technology to the rural sector.

In all about 65 projects, have been identified by the groups on Khadi and Village Industrie involving a financial outlay of about Rs. 4.89 crores. Projects identified by the group o rural buildings amount to Rs. 2.82 crores. However, as further projects are being identifie encompassing larger number of village industries, an *ad hoc* sum of Rs. 15 crores is being sough for the Ministry of Industrial Development, under which the main implementing agency, namel the Khadi and Village Industries Commission, is functioning. The project for mobilisation o services of students of IIT's, engineering colleges, etc., requires an additional outlay of abou Rs. 2.75 crores which is to be separately handled by the Department of Science and Technolog Thus, the total outlay for all the above programmes is estimated at Rs. 17.75 crores.

The outlays recommended by the various groups are as given below :—

No.	Group	Financial Outlay (Rs. in lakhs)
S24G1.	Khadi	48.36
2.	Village Industries	440.51
3.	Materials of construction :	
(i)	Pilot plant production of Rural Materials—Research and Development	219.00*
(ii)	Village level cement production using Rice Hisk and Limestone	19.00*
(iii)	Integrated Technology for Rural Industrial Development Systems Analysis	43.36
4.	Silk	200.00
5.	Coir	151.00
		1,121.23
		1,500.00**
6.	Mobilisation of Academic Institutes for Integrated Rural Development	275.00*
	TOTAL :	1,775.00

*Identified by the panel on Housing and Urbanisation;

**As further projects are being identified encompassing large number of Village Industries, an *ad-hoc* provision is made.

The details of various project are given below :

roject ndex No.	Project	Financial Outlay (Rs. in lakhs)
1	2	3
	G$_1$ GROUP ON KHADI	
	A$_1$—Cotton Khadi	
$S_{24}G_1A_1P_1$	Design pre-opener with Lap former	0.40
2.	Design and develop carding machines with flates and combing arrangements	0.30
3.	Develop draw-frame for above	0.12
4.	Develop fly-frame for preparing rovings for 480 spindles	0.16
5.	Develop semi automatic loom with weft stop motion	0.10
6.	Design multispindle spinning frame with modification to increase front roller delivery	0.20
7.	Develop non-edible cheap material for sizing	0.05
8.	Develop high drafting systems in spinning and complementary field test	4.37
9.	Evolution of designs	8.52
10.	Desizon and develop pre-weaving equipment as warping, sizing, etc.	0.50
11.	Buildings, equipment, machines and testing instruments	3.00
12.	Development of dyeing & printing machines	6.00
13.	Field Research and experiments with the above developed machines in four different places	17.00
	A$_2$—Muslin Khadi	
$S_{24}G_1A_2P_1$	Design pre-opener combing machine, drum drawframe, carding machine, calender draw frame (power driven) and composite high draft (7-spindle) Apron Charkha (Hand Driven).	2.00
	A$_3$—Wollen Khadi	
$S_{24}G_1A_3P_1$.	Adoption of 6-spindle new model charkha	0.64
2.	Field trials, research and experiment under woollen and muslin khadi	5.00
	Total G$_1$	48.36
	G$_2$ GROUP ON VILLAGE INDUSTRIES	
	A$_1$—Village Oil Industries	
$S_{24}G_2A_1P_1$.	Improving the efficiency of oil processing equipment	4.47
2.	Study of oil processing in ghani and suggest improvements for increasing the efficiency by working out optimum conditions	3.65
	A$_2$—Village Leather Industry	
$S_{24}G_2A_2P_1$.	Design and fabrication of	
	(a) a dry rendering plant for production of sterilised meat and bone meal with facility for packing.	2.63
	(b) a kiln for conversion of raw bones into bone ash	1.10
	(c) a small machine and/or appliance for stitching raw hides into bags for tanning bag tanned leather.	0.69
	(d) a small hot plating machine for finishing of chrome upper leather having capacity of 20 to 30 pieces of leather per day.	4.21

1	2	3
	A_3—Fibre Industry	
$S_{24}G_2A_3P_1$.	Design and fabrication of better implements for fibre industry	2.78
	A_4—Gobar Gas Scheme	
$S_{24}G_2A_4P_1$.	Measures for accelerating fermentation in plant	5.00
2.	Devising burners of more than 60% efficiency	1.00
3.	Development of alternative materials and for designing lower cost more efficient plants	20.00
4.	Extension services and popularisation	20.00
5.	Gas from human excreta akin to Gobar-gas plant, its development and popularisation	20.00
	A_5—Handmade Paper Industry	
$S_{24}G_2A_5P_1$.	Development of the following two industrial papers *viz.* (a) Jaquard Boards and (b) Electrical Insulation Paper.	3.00
	A_6 Palm Industry	
$S_{24}G_2A_6P_1$	(*a*) Devise suitable aid for climbing palms. (*b*) Design efficient boiling and crystallising equipment for palm candy (*c*) Design suitable equipment for sterilising and bottling of Neera. (*d*) Introduce efficient fibre extractors and brush making machine for palm fibre.	3.63
2	(*a*) Preservation of palm juice and its products. (*b*) Clarification of palm syrup and molasses. (*c*) Development of new products from palm gursugar and molasses	2.05
	A_7 Cottage Match Industry	
$S_{24}G_2A_7P_1$	Design and fabrication of hand operated labelling, box making, splints and veneers making machines and machine for preparing booklet splints for match industry (Hand operated Prototype).	6.48
2	Formulation of process/es for timber, other than soft match wood, for preparing substitute for soft match wood required for production of splints and veneers and formulation of cheap chemical composition for tip and side paint using substitutes of scarce/imported chemicals.	2.53
	A_8 Village Pottery Industry	
$S_{24}G_2A_8P_1$	Development of common clay pottery pipes (teracotta hardbacked) with suitable mechanical shaping device.	5.35
2	Small continuous kiln (Bhatta) for brick making using slack coal or fire wood.	3.00
3	Design efficient pottery kilns for (a) pots and pans (b) tiles (c) bricks (d) whiteware glazed pottery (earthenware and stoneware) suitable for different fuels (wood, coal and oil).	3.00
4	Design small and efficient pug-mill for common clay	2.00
5	Design machinery and techniques for the production of high quality flooring tiles—fine grained, dense impervious to water.	3.00
6	Develop low cost flooring techniques in the shape of red clay and extend its use along with the roofing techniques and super structure techniques.	18.35
7	Develop power driven potters' wheel with speed regulator.	1.50
	A_9 Lime Industry	
$S_{24}G_2A_9P_1$	Development of various types of kiln design-engineering technology	5.60
2	Manufacture of hydro-cement (cementing material) out of Kankar nodules and tannery waste.	4.48
3	Substitution of cement by lime in making irrigation pipes, tiles, hollow bricks etc. (Process Technology).	1.30
	A_{10} Processing of Cereals & Pulses	
$S_{24}G_2A_{10}P_1$	Paddy processing unit	3.75
2	Domestic atta chakki	0.23
3	Power operated dal chakki	1.19

1	2	3
	A_{11}—Gur and Khandsari Industry	
$S_{24}G_2A_{11}P_1$	Improvement to the existing bullock driven crusher by incorporating vane preparatory device and providing static hydraulic load-on roller of the bullock driven crusher. Modification project on Dorolux sugarcane juice extractor.	3.91
2	Evaluation of continuous juice settler suitable for khandsari units.	3.46
	A_{12}—Beekeeping Industry	
1	Improvement in the performance of Indian honey bees.	57.56
2	Assessment of the utility of Indian honey bees in increasing crop yields and quality due to planned bee pollination.	16.11
3	Bee-Plant test garden and nursery.	4.33
4	Exploitation of flora in inaccessible forests and economising management expenses.	4.92
5	Criteria for distinguishing extracted apiary honey from squeezed honey and quality control of other bee products like beeswax, royal jolly bee venom and bee collected pollon.	3.04
	A_{13}—Non-Edible Oils and Soaps Industry	
$S_{24}G_2A_{13}P_1$	Devising seed driers and power driven decorticators for rubber seeds, dhupa seeds, mohua kernels and neem fruits.	59.63
2	Developmental research on the utilisation of lipids, and its seed meals of minor and non-edible oil seeds.	22.62
	A_{14}—Cane and Bamboo Industry	
$S_{24}G_2A_{14}P_1$	Evolving suitable machinery for splitting bamboo for splints for making mats, baskets etc.	8.96
	Establishment of a multidiciplinary R&D laboratory and workshop.	100.00
	Total G_2	440.51

GROUP ON MATERIALS OF CONSTRUCTION*

A_1—Rural Materials Research & Development

$S_{24}G_3A_1P_1$	Soil Stabilised Bricks/Building Units.	(a) Investigations on soil stabilisers.	1.0
		(b) Bomboo reinforced soil cement/lime pozzolana building unit and extension work.	3.0
		(c) Investigations about the economics of production of soil stabilised bricks by establishment of demonstration pilot plants in various places.	6.0
2	Burnt clay building bricks and tiles.	(a) Imprvoements in the efficiency of the bricks klns and esetension work.	5.0
		(b) Development of economical process for manufacture of clay flooring tiles.	2.0
		(c) Setting up demonstration-cum-training centres to serve as	40.0
		(d) Prote-type for imparting training in improved methods of production of bricks (ii) training to inservice moulders/ fire-men and (iii) development of processes for production of durable and cheaper rooling tiles.	
3	Building Lime.	Demonstration-cum-training centres for improved technique of burning lime and hydration of lime, particularly production of dry hydrated lime, especially for rural areas.	80.0
4	Clay Pozzolana.	Training-cum-demonstration centres for manufacture of lime-clay pozzolana mixture in each State.	10.0
5	Red Clay Sanitary Ware.	Extension of R&D in manufacture of sanitary ware from red burning clays on semi-commercial scale.	2.0
6	Timber.	R & D in development of cheaper chemicals for treatment of timber, especially in rural areas.	1.5
7	Fire Proofing of Roofs.	Investigations about fire proofing of roofing materials of organic origin.	3.5

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*Projects identified by the panel on Housing Urbanisation and Construction Technology.

1	2	3	4
8	Building Materials from Agricultural Wastes.	Development of building materials from rice husk, jute stack, ground-nut husk, etc.	3.0
9	Building Bricks from Laterite.	Development of improved process for manufacture of bricks from lateritic soils.	2.0
10	Stone Slates, Limestones, etc.	R&D in the use of stones slates, limestone, etc. for manufacture of building materials.	2.0
11	Coconut husk, Pith Fibre as building material.s	(a) R&D on drying of pith.	2.0
		(b) R&D of processes for use of coconut husk, pith fibrous wast for hard boards, particle boards, insulation, blocks, etc.	3.0
		(c) Pilot Plant investigations of coir reinforced roofing board including extension.	5.0
12	R&D of new materials, Performance standards for new materials.	Performance evaluation of new building materials.	3.0
	(a) Setting up of pilot plants for Industries to produce materials, building components (bricks, pipes, tiles) etc. in various regions of the countries.		100.00
	(b) Survey and investigation of raw materials for suitability for construction materials industries.		
		Total G_3A_1	219.00

A_2—Village Level Cement Production

$S_{24}G_3A_2P_1$	Village Level Cement production using rice husk and lime-stone.	19.00
	Total G_3A_2	19.0

A_3—Integrated Technology for Rural Industrial Development

$S_{24}G_3A_3P_1$	Integrated Technology for rural industrial development-systems analysis (Oriented towards building materials/product industries, industries oriented towards production of water supply (pot chlarinaters) sanitary privy etc.) (i) Survey & identification. (ii) Establishment of Field Laboratory. (iii) Establishment of Development Units	43.3
	Total G_3A_3 .	43.3
	Total G_3	281.3

G_4—GROUP ON SILK

$S_{24}G_4P_1$	Central Sericultural Research Training Institute, Mysore	61.5
2	Central Tasar Research Station, Ranchi and 3 sub-stations	91.3
3	Central Sericultural Research Station, Behrampur	17.1
4	Central Moga & En. Research Station, Titabar, Assam	20.0
5	Univoltine Research Sub-Station, Majra (U.P.)	10.0
	Total G_4 .	200.0

1	2	3
	G_5—GROUP ON COL	
	A_1—Product Diversification	
$S_{24}G_5A_1P_1$	Investigation on production of Japan mats/Automats	51.80
2	Mechanical extraction of coir from coconut husks and utilisation of the extracted fibre.	
3	Rubberised coir	
4	New uses of coir mattings.	
5	Industrial utilisation of coconut husk/coconut pith	
6	Utilisation of coconut pith development of a suitable drying system at economic cost.	
7	Investigation on manufacture of needled coir pads	
	A_2—Produce Development	
$S_{24}G_5A_2P_1$	Retting	37.30
2	Fibre extraction	
3	Spinning and Coir yarn	
4	Improved Dyeing techniques for faster shades	
5	Development of Improved design and patterns	
6	Improvement in techniques of production of creel mats	
7	Improved techniques for weaving coir mattings in novel designs	
8	Research assistance to coir establishment	
9	Quality Improvement	
10	Technical collaboration	1.50
11	Programme execution	2.20
12	Establishment of a dye-house	58.29
	Total G_5	151.00
	G_6—MOBILISATION OF ACADEMIC INSTITUTES FOR INTEGRATED RURAL DEVELOPMENT	
$S_{24}G_6A_1P_1$	Development & Extension Programmes Negarding Rural/Village industries development and employment generation.	275 lakhs
2	Rural Water Supply, Sanitation (including drainage), Public Health. Rural Road Programmes. Environmental Improvement.	
3	Rural Housing/Buildings "Incremental" type Housing Schemes. Improvement of Physical Environment. Village Planning. Market Towns for aggregate of villagees.	
4	Agriculture Extension	
p	Health & Family Planning, Medical Care, etc.	
6	Other social welfare programmes—Education extension.	
	Total G_6	275.00

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*A total of 20 centres with central regional coordination.

SECTOR--UTILISATION AND RECYCLING OF WASTES

UTILISATION AND RECYCLING OF WASTES

ntroduction

1 1. By effective utilisation of wastes, it is possible for us to conserve available national urces and reduce cost of production, as well as in many cases, to solve the problem of ition of the human environment. As a result of increasing industrial activity and urbanisation, nal utilisation and disposal of wastes has assumed importance both to avoid public hazards nvironmental pollution and to conserve resources. There are large quantities of wastes and roducts of agriculture including forestry, animal husbandry, fishery and agro-industrial es, which could be utilised. Many of such wastes are at present used in an uneconomic ner or left completely unutilised *e.g.* husk, straw, corn cobs, non-edible vegetable oil-seeds, ior fibres, nutshells, feathers and bones, sea-weeds, etc. Wastes from steel plants (slag), ng, metallurgical, manufacturing and chemical industries can be used as a very valuable urce for making building materials, chemicals etc. In some of the developed countries of world, these wastes are usefully exploited and add to the national wealth. Even a country China, makes as much as 300 million dollars per year by recycling 50 million tonnes of es, as per newspaper reports. Modern advances in science and technology have led to profitable utilisation of such products. Because of the tremendous magnitude of the blem in India, there is a tremendous need for augmenting the present research and develop-t work in this field to a level that can be used for implementation so as to add to the onal wealth. From the wastes, Japan has made tremendous stride in getting wealth from es. Table 1 gives an itemised list of wastes and by-products and the present status in India.

1 2. *Classification.*—Some of the more important wastes and by-products may be classified the following categories according to their sources :—

(a) *Agricultural and forestry wastes.*—Non-edible oil-seeds, wastes from fruit and vegetable processing, bagasse and press-mud from sugar factories, saw dust and other wood industry wastes, tobacco wastes and seeds, rice husk, bran, tea waste, etc.

(b) *Animal Wastes.*—slaughter-house wastes, animal carcasses, fishery wastes, leather and wool wastes, etc.

(c) *Industrial and Mineral Wastes.*—Blast furance slag, coal ash including fly-ash, mica wastes, metal scraps, extraction of lead and strontium from used batteries, wastes from chemical industries, etc. Among other areas for utilisation of industrial and mineral wastes can be included metal scraps, particularly non-ferrous metals, wastes from pulp and paper mills, distilleries, fertilizer factories, petro-chemicals, pharmaceuticals, rayon pulp mills, tanneries; extraction of lead, zinc, strontium from used storage batteries.

(d) *Urban Wastes—Rural Wastes ("Community" Wastes).*—

(i) Solid wastes including sweepings, garbage, kitchen waste, night soil.

(ii) Liquid wastes including sewage and sullage comprising all waste water and night soil.

(e) Some may be classified according to their end use; such as Building Materials fr Agro-Industrial, Mineral Wastes etc.

Table I showing list of wastes, their use and present position and the work done by the laboratories or institutions India. (An illustrative list—not purported to be comprehensive).

Waste	Use and present position	Work done in Lab./Institut
1	2	3
I. Agricultural Wastes (See also item IV)		
1. (a) Non-edible oil-seeds of neem, mahua, Kusum, karanj and undi.	There are at present 80 different oil-bearing trees with an estimated annual production of about one million tonnes of minor oil-seeds. More than 40% of oil-seeds come from neem and 20% from mahua. Only a fraction of these oil-seeds are collected and crushed in mills or in villages, totalling only about 70,000 tonnes. An efficient programme of collection and crushing of these oil-seeds can lead to a prodcution of about 0.3 to 0.4 million tonnes of oil cakes along with considerable quantities of oils and fats for use in various industries like soap-making, medicine, etc. The oil cakes contain 2.5 to 5.2% of nitrogen and 0.8 to 1.6% of P_2O_5 and can be used as a manure.	The Regional Research La Hyderabad has worked methods for splitting and covery of fatty acids from n edible oils derived from th seeds.
(b) Sal seeds available in forest areas particularly in Orissa.	There are about 40,000 tonnes of sal seeds produced annually.	As a result of researches cond ted by the ICAR and CFT arrangements have been m for the collection of sal se on a commercial scale and lat it is understood that the se are being used for extract of oil. Investigations c ducted on residual cakes sh that this cake can be utili for feeding poultry, pigs a cattle.
(c) Groundnut cake after extraction of oil.	It is used as a human food as it contains 45 to 50% of protein. At present, the groundnut cakes are generally used for cattle feed and also as fertilizer. It is estimated that annually 2 to 2.5 million tonnes of groundnut cakes are available in the country.	In CFTRI, Mysore, work been carried out to make of de-oiled groundnut ca different products of hig nutritive value. The work resulted in the preparation edible quality groundnut fl (free from toxic factors) wh is now used as a compon for high protein feeds like Ahar, multi-purpose food a fortified atta. The work also resulted in the prod tion of protein isolate wh can be conveniently used as protein fortifier in vario foods.
2. (a) Rice bran	At present, rice bran, a by-product of rice milling industry, is mostly used as a cattle food. A limited amount is also being processed for extraction of industrial grade oil by solvent extraction. 6 to 8% of bran is recovered under the existing conditions of milling and the total quantity of rice bran estimated to be available is about 2.4 million tons in the country.	In CFTRI, work has been carr out to prepare rice bran that can be used for edi purposes. Processes for production of amylase, an loglucesidase and pectinase zymes have been standardi by utilising wheat bran a de-fatted rice bran. The mand for these enzymes is tonnes per annum. Proc has also been evolved producing activated carb from rice bran.

1	2	3
b) Rice husk.	Furfural; silicate refractories (Silicon Tetra-chloride), other chemicals; building materials (like cement).	Work is being done at RRL, Jorhat and IIT, Kanpur.
Tea Waste	At present, a large amount of tea waste of the order of 8,000 to 9,000 tonnes is burnt. In the processing of tea, 2% waste is obtained which contains 2 to 3% of recoverable caffeine i.e. about 160 to 180 tonnes on total tea waste. Import of caffeine during 1969-70 amount to 5883 kgs. valued at Rs. 1.27 lakhs.	The Regional Research Laboratory, Jorhat has developed a process for the production of caffeine from tea waste. It is claimed that the cost of production by the process developed at the laboratory would be Rs. 20 per Kg. as against the present market price of Rs. 100-120 per Kg. A plant with a capacity of 120 tonnes capacity per year has been set up in Assam.
Bagasse (fibrous material left over by cane crushing in the manufacture of cane sugar)	Used mainly as fuel in sugar factories and partly in admixture with pulp for making paper. The rational use would be in the making of paper due to shortage of conventional cellulosic materials, like bamboo, hemp, etc. In that case, a cheaper fuel than bagasse has to be investigated. Production of cane sugar in 1969-70 was 4.2 million tonnes. From 8 T of cane crushed, one tonne bone-dry bagasse is obtained. The quantity of bagasse available can be estimated at 5.25 million tonnes, Dry bagasse consists essentially of fibre and pith. The fibre content is about 65% of dry weight and the pith including soluble matter constitutes the remaining 35%. The fibre is suitable for manufacture of paper of good quality. The pith, on the other hand, has no value as a paper-making material and pulping of the bagasse containing pith leads to larger consumption of chemicals used for digestion, difficulties in washing and bleeching the pulp, slow rate of draining of the stock on the paper machine and less capacity of the resulting paper. It is, therefore, necessary to separate the pith from the fibre for the manufacture of paper. The separation of pith has to be undertaken in the sugar factories in order to reduce the baling, storage and transport charges on the bagasse meant for paper production. The pith can be used as a fuel in the sugar factory. On the basis of 5.25 million tonnes of dry bagasse available in 1969-70, it can be calculated that about 3.34 million tonnes of fibre would be available for paper manufacture.	Ministry of Industrial Development sponsored a study on utilisation of bagasse for paper-making. The scheme did not make much headway because the sugar mills wanted some subsidy from the Government to convert their bagasse burning boilers into oil or coal burning boilers. Similarly, they found that the sale proceeds of the bagasse were less than what they would have to pay for the purchase of coal. Bagasse containing 45 to 50 per cent moisture has a calorific value of about 4,400 BTU/Pound as against 12,600 BTU/Pound of coal of good grade. Thus, in terms of fuel value coal bagasse is 5:2, i.e. on weight basis, one tonne of Grade I coal would replace 2.5 tonnes of bagasse provided the boilers in the sugar mills are of the type which can switch over to coal without any modifications.
Tobacco waste.	The present amount of tobacco waste is estimated at 62,000 tonnes. Out of this, two-third is used for manurial purposes and to some extent as insecticide and the remaining one-third is wasted. Tobacco contains one to three per cent of nicotine.	At the National Chemical Laboratory, a process has been developed for the production of nicotine sulphate solution (40% nicotine) from tobacco waste. The process has been released to four parties for exploitation. Besides nicotine sulphate, manufacture of nicotinic acid can also be taken up as a by-product of nicotine sulphate industry.
Proteins from plants.	Considerable amount of protein can be extracted from plants. Also from trees Polysaccarides, lipids and proteins can	Indian Statistical Institute, Calcutta. NCL, Poona. FRI, Dehradun. ICAR Laborato-

1	2	3
	be extracted. An extraction device has been evolved in the plant protein research units of Indian Statistical Institute.	ries have shown the potenti in their laboratory investig tions.
7a. Saw-dust	Utilized in a number of ways as is evident from the following list :	Laboratory level work bein carried out at the following plac
	(i) Activated carbon using saw-dust from softwood.	RRL, Hyderabad.
	(ii) Oxalic acid from sawdust.	RRL, Jorhat.
	(iii) Phenolic moulding powder from sawdust.	RRL, Jorhat.
	(iv) Particle board from wood-waste without binder.	RRL, Jorhat; IPIRI Bangalor
	(v) Hardboard from sawdust.	RRL, Jammu; IPIRI, Bangalore
	(vi) Woodwool waste board from wood-dust.	FRI, Dehra Dun.
	(vii) Distillation oil from the sawdust of *Eucalyptus Citriodora*	FRI, Dehra Dun.
	(viii) Furfural from sawdust.	FRI, Dehra Dun.
	(ix) Protein food from cellulosic materials.	NCL, Poona.
	(x) Fuel oil from cellulosic wastes.	RRL, Hyderabad.
	(xi) Sawdust as a mulching material.	
	(xii) Sawdust as a bedding material for animals.	
	(xiii) Sawdust as a manure in tropical soils.	
	(xiv) Sawdust as a packing material.	
	(xv) Alchohal from saw dust.	
7b. Other Agricultural wastes.	(a) Production of furfural, Alchohal,	RRL, Jorhat.
	(b) Use in Paper and Pulp industry.	FRI, Dehra Dun.
	(c) Agricultural wastes and by-products as cattle feed.	
	(d) Preparation of activated carbon.	
	(e) Fire retarders from cashewnut and arecanut oils/ resins.	CBRI, Roorkee.
	(f) As manure.	CPHERI, Nagpur.
	(g) Use of cotton dust of textile mills for making compost.	RRL, Jorhat.
8. Coconut wastes/by-products (other than those used for construction materials)		
(a) Coconut shell.	About 0.88 m. tonnes of shell are available. At present used as fuel and for manufacture of fancy articles and miscellaneous household articles.	NCL, Poona—destructive di tillates of coconut shell. FRI, Dehradun/IPIRI Bangalor coconut flour as a filler f synthetic resin glues, filt and extender for phonol moulding powder.
(b) Coconut husk.	About 6,000 million tonnes is available in coconut producing areas. Only 50% is used in the coir industry.	FRI, Dehra Dun-high strech pape with 10% long fibre pulp.
(c) Coconut water.	About 0.5 million tonnes of water available. Used only as a soft drink.	Manufacture of antibiotics. A a rubber coagulant. As source of potash in agricultur In vinegar manufacture.
9. Arecanut wastes/by-products (other than those used for construction materials)		
(a) Arecanut husk.	1 lakh tonnes available. Used as a poultry feed.	FRI, Dehra Dun-brown wra ping paper. CPCRI, Regional Station, Vitt is collaborating with variou agencies to find out its eco nomic uses.
(b) Leaf Sheath.	About 90,000 T/annum available in the country used as a thatch or making brooms.	No significant work has bee done.

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(c) Choganu liquid of 'kali'	No estimate available. At present wasted.	CLRI, Madras—tannins from 'Kali'
. **Cashew wastes/By-products (other than those used for construction materials)**		
(a) Cashew Apple.	About 30m Tonnes available. Used for 'Femi' preparation in some regions.	CFTRI, Mysore—Preparing a variety of beverages, liquors and other products after removal of astringent and aeried principles.
(b) Cashew testa.	About 3-4 thousand tonnes available. It contains about 61 % tannin. At present used for only burning in the factories.	CLRI, Madras, has developed a process for extraction of tanin from cashew testa.
(c) Cashew nut shell liquid.	About 10-14 thousand tonnes available. Only 1,000 tonnes indigenously used. Finds applications in the paints, varnishes, automobile and foundry Industries.	RRL, Hyderabad. NCL, Poona.
1. **Cotton Wastes/by-products.**		
(a) Cotton stalks	Approx. 25m T. available/annum. Used as fuel in villages.	No significant work done. Can be used as raw material for dissolving grade pulp/hardboard packing material.
(b) Cotton leaves.	No data available on availability. These are a rich source of organic acids.	IARI, Delhi has done work on their organic acid content (citric acid, malic etc.)
(c) Cotton linters.	Available in A.P., Bombay, M.P., Madras, Mysore, Punjab, Rajasthan and U.P. etc. Seed with linters used as cattle feed and also for sowing.	Can be used for acetate rayon, Cellulose lacquers etc. RRL, Hyderabad, NCL, Poona and CTRL, Bombay are working on chemical diluting of cotton seed and other related aspects.
2. **Jute wastes/By-products.**		
(a) Jute stick	About 2.5m tonnes available from 64 jute growing districts. At present used only for burning and fencing purposes.	JTRL, Calcutta has worked out the possibility of converting jute stick to paper, newsprint, kraft paper, box board, particle board, viscose rayon etc.
(b) Jute Mill Waste	This consists of caddis, comprising short fibres and fluff, jute waste & the shaken dust. Total quantity available may amount to 50,000 tonnes. At present used as a supplementary fuel in boilers.	No work has been done.
3. **Wood Wastes**		
(a) Saw dust	(See item 7 above)	
(b) Bark from industrial wood like veneer logs.	About 0.3m tonnes available. Used only for burning purposes.	FRI, Dehradun has initiated some work on 'chemicals from wood distillates'.
I. **Community Wastes**		
4.(a) Night Soil, sewage sludge, cattle dung, urine.	Only in few cities and towns, there is an efficient sewage disposal system which gives rise to sewage and treated sludge as manures. Sewage sludge contain high nutrients. The annual potential quantity of nitrogen, P_2O_5 and K_2O available from the night soil and urine in the country is estimated at about 7 million tonnes of dry matter containing 2 million tonnes of nitrogen, 0.5 million tonnes each of P_2O_5 and K_2O.	The Central Public Health Engineering Research Institute Nagpur has developed a process for making manure and fuel gas from night soil sewage sludge and cattle dung. The gas is used for its fuel value. The digested matter can be used as soil conditioner as it has manurial values.
4(b) City refuse	Arrangements for night soil compost making is too inadequate in many cities. However, in recent years, composting of town refuse and night soil in trenches are being practised and advocated. About three million tonnes are being prepared annually. The total quantity	The Central Public Health Engineering Research Institute has made compost from city refuse yielding a very good material for soil conditioning. Jadavpur University IIT, Kanpur.

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	of nitrogen thus saved and used for manuring land works out to be less than 10% of the country's potential. Survey regarding viability of composting in different areas and innovations in mechanical composting need to be done.	
15. Slaughter-house wastes	The total loss sustained by the country in respect of non-utilization of animal by-products and wastes is estimated to be Rs. 29 crores per annum. Moreover, the by-products can be used for the production of various products like stearin, casings, gelatine, poultry feed etc. The country produces about 27,000 tonnes of animal intestines per annum. Most of these go waste. One per cent of these is only exported to earn Rs. 120 lakhs per annum as foreign exchange. It is estimated that nearly two-third of the 55,000 tonnes of blood available is wasted which is valued at about Rs. 1 crore. Animal blood when dried produces blood meal containing 10 to 12% nitrogen and 1 to 2% of P_2O_5 which after proper sterilization could be used as a top-class stock feed. Nearly 12 million carcasses of large animals are available annually. Excepting hides, horns and bones, the rest are allowed to go waste. Slaughter-house meat waste, if processed, would give rise to 0.12 million tonnes of meat meal manure.	The Central Leather Research Institute has developed a process for making blood meal out of this waste. Its suitability in poultry feed formulations has been established. Work is also done in IVRI, Izatnagar and other ICAR laboratories regarding utilisation of the wastes from dead animals—Raw bone meal, Meat Meal, Glue Gelatine. A report by CSIR has published the work of task force on "Abattoirs and Animal products", headed by Dr. Parpia of CFTRI in 1972.
III. Industrial Wastes		
16. Paper Waste. "Recycled Paper Products"	At present, the old newspapers are used as rags and wrapping material. The country is importing nearly 1.2 lakhs tonnes of newsprint per annum. Also, paper from wastes of cotton, jute, bagasse can be produced. Recycled paper is also another important developmental project.	The Regional Research Laboratory, Jorhat has developed a process for de-inking of this waste paper rags for re-conversion into newsprint. By this process, it is claimed to produce newsprint at a cost of Rs. 1150 per tonne. Use for cement pulp sheets and corrugated boards for roofing and insulation.
17. Mica waste	India is the largest producer of mica in the world earning Rs. 10 to 12 crores per annum through export . In mining operations, about 35 to 90% of total mica mined goes as waste, the yearly accumulation being of the order of 20,000 tonnes.	The Central Glass and Ceramic Research Institute has developed several commercial uses of mica waste. Know-how has been developed for making heat-insulating materials comparable in performance and properties to vermiculite and imported diatoamite bricks which are used as backing insulation in industrial furnaces, boilers etc. These bricks worth Rs. 1.5 crores are used in steel plants, oil refinaries and power plants. The Institute has also developed a process for the production of wet ground mica which has good demand. The Institute has also developed different types of paints from mica powder used at present by the Indian Railways.
18. Fly ash.	Fly ash is an industrial waste from thermal power stations. During 1968-69, the quantity of fly ash available was estimated at 5 million tonnes. It is expected to be doubled in the next few years. At pre-	The Central Building Research Institute and Cement Research Institute of India have conducted investigations on the utilization of fly ash as a pozzolana

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	sent, the various thermal stations dispose fly ash in slurry form to the neighbouring disposal areas. To a limited extent, it is also being used as a building material. Fly ash from Neyveli is being used in the manufacture of solid and hollow building bricks with replacement amounting to 20% and also in mass concreting for dams in Tamil Nadu and Kerala. Products which can be developed are : (a) Portland Pozzolana Cement. (b) Light weight Aggregate. (c) Lime fly ash bricks. (d) Silicate bonded fly ash bricks. As a result of the proposals by NCST, and CSIR Cement Research Institute (CRI) and Central Building Research Institute carried out techno-economic feasibility studies on items (a) and (c) in 1972-73 for actual setting up of plants. CRI had carried out studies regarding Intergrinding and Interblending plants in Delhi-Badarpur-Faridabad complex. Recommendations have been made to Cement Corporation of India and Ministry of Industrial Development for setting up of a plant.	in concrete as portland pozzolana cement, in the making of light weight aggregate and in making bricks in admixture with clinkers. The Central Fuel Research Institute has developed techniques for production of common bricks out of fly ash. In the thermal power stations, besides fly ash, sulpur dioxide is also emitted which is let into the air through stacks. A point arises whether sulphur should be recovered from fly ash as it is in short supply in the country and is presently imported. It is generally believed that Indian coals have normally low sulphur and recovery from fly ash would not be an economic proposition. However, further research will be necessary in this field. NBO has worked extensively on uses of fly ashes from different thermal power plants. Work is under way at the National Metallurgical Laboratory, Jamshedpur on the recovery of germanium from fly ash and flue dust. For this purpose, fly ash and flue dust have been collected from thermal power stations and were smelted with caustic soda, lime, copper oxide and coal dust to produce metallic regulus. Regulus containing all the germanium tetrachloride on treatment with water produces germanium dioxide. Thus, metallic germanium is produced. The studies have shown that minimum germanium in the ash is 200 parts per million.
By-products of salt industries.	Nearly 4 million tonnes of common salt is annually produced in India mainly from sea-water and lake brines. From the salt bittern, potassium chloride magnesium sulphate, magnesium chloride, sodium sulphate, bromine, borax, etc. can be recovered as by-products. Of this, potassium chloride is particularly important as a source of potash to crops. It is estimated that nearly 50,000 tonnes of potassium chloride are associated in the present production of salt.	The Central Salt & Marine Chemicals Research Institute has carried out work on (1) recovery of by-products from waste liquor of salt industry and their utilization in the production of chemicals, (2) sodium sulphate from sambhar bitterns (3) potassium chloride from salt petro sludge, & (4) calcium carbonate from calcium chloride (waste liquor in soda ash industry). One unit for production of potassium chloride from mixed salt has been set up at Kandla. A pilot plant for production of magnesium oxide of the capacity of 150 tonnes per annum is in operation. This is used in the manufacture of refractories for steel industry.
Wastes from steel plants (Slags)	It is only recently that granulation plants have been set up as part of Steel Plants. (The Bhadravathi and Rourkela Steel Plants have granulation plants.) Blast furnace slag cement.	Cement Research Institute of India (CRII) and Central Building Research Institute (CBRI) have done work on this topic. CRII is strengthening its activity to use these slags for

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		manufacture of slag-cemen super sulphated cements, an light-weight aggregates.
IV. Construction Materials from Wastes: (see item I)		
21. Wastes from sugar factories (Carbonation Press Mud).	This is a good source for making hydraulic masonary limes and for manufacture of portland cement.	CBRI has developed a proces for manufacture of lime.
22. Use of Agricultural wastes for building materials.	A valuable resource for making building boards and panes.	CBRI; RRL, Jorhat have don laboratory level studies.
23. Coconut, cashewnut and Arecanuts after extracting oils.	Building boards for insulation purposes: Particle board and Expansion Joint filler from coconut husk, pith, fibre, rice straw, groundnut husk, jute stickes, baggasse and wool.	CBRI, Roorkee IPIRI, Bangalor RRL, Jorhat have done prel minary work.
24. Red Mud from Almuinium Industry.	Building bricks/expanded blocks for structural and insulation purposes.	CBRI has done preliminary wor regarding the above.
25. Water Works Silt.	Lightweight aggregates can be made.	CRII, and RRL, Jorhat hav carried out laboratory studies.
V. Animal Wastes		
26. Fisheries wastes.	(i) Agar-agar, agarose and sodium alginate from seaweeds.	Work is in progress at CSMCR Bhavnagar.
	(ii) Animal food production from waste water.	NBG, Lucknow and CFTR Mysore have initiated work.
	(iii) Fish protein concentrate, fish meal, from lobster wastes, sharkliver residue etc.	RRL, Bhubhaneshwar has don some work.
	(iv) Proteins and amino acids from marine algae.	CSMCRI has initiated work.
	(v) Shrimp waste as poultry feed. Also item 15—Slaughter house wastes.	CFTRI has carried out laborator level studies.
27. Prawn wastes.	About 40,000 tonnes of prawn wastes in the form of head and shell are available from the processing factories. At present it is used only as a manure or cattle/poultry feed.	CIFT Cochin has prepare chitosan which has good po tential in textile industry an also a product called skrim extract for human consumption.
28. Squilla.	About 1,00,000 tonnes is annually caught but is normally thrown back into the sea.	No significant work has bee done. Squilla is a good sourc of chitasan an important chem cal for the textile industry.
29. Frog wastes	About 5,000 tonnes of this waste is annually available in the form of body and fanc-legs.	No work has been done. It i reported that frog oil is beneficial in the treatment o 'asthma'.
30. Carcasses utilisation	It is estimated that about 125 lakh carcasses of large animals are annually available. Usually only the hide and some of the bones are collected while the meat, fat, horns, hoofs etc. are allowed to go waste. Due to defective flaying and improper curing, the country loses Rs. 5 crores annually and Rs. 22.5 crores through non-utilisation of the other components of carcasses.	KVIC has formulated variou schemes for the development o carcass utilisation by co-operative societies etc. The Madra veterinary College has als set up a 'Flaying Section' to impart training in Scientifi Flaying and curing of Hides to amateurs and Butchers sinc 1953.
VI. Miscellaneous Wastes from the Fruit and Vegetable Processing industries		
31. Mango peels] & Kernels	These constitute about 50% of the weight of fresh mangoes.	CFTRI, Mysore has develope a process to obtain starch fron seed Kernels which can be used to partly replace whea atta for making chapatees oil which forms about 12% of the weight of the kernel is another by-product.

1	2	3
Citrus peels pomace etc.	These account for nearly 40% of 1.2 million tonnes of annual citrus fruits in the country.	CFTRI, Mysore has developed an integrated process for economic recovery of oil and protein from the peels of oranges and lime. These products have good internal and external demand.
. Apple pomace	It is left over after preparation of juice. Its pectin content varies from 2.5-3.4% on fresh weight basis.	CFTRI, Mysore, has developed a process to prepare pectin, cider and vinegar from pomace.
. Pineapple peels, ears and eyes.	These wastes contain 7-8% sugar.	CFTRI. Mysore has standardised a method to prepare syrup out of this juice by using ion exchange resins and also vinegar directly from the processed juice. The residue can be utilised as cattle feed.
5. **Banana Psevdostem.**	It contains nearly 90% water, 0.5-3.0% starch and 5-8% fibre.	CFTRI, Mysore has developed a process to recover starch and fibre from the banana stem. Starch has been found to be useful in food, cosmetics and textile industries and fibre in the manufacture of paper and pulp.
6. Wastes from the vegetable canning industries.	No significant data is available on these aspects.	

UMMARY :

Projects have been identified in such areas as :

1. Agricultural and Animal Wastes.
2. Wastes from the Chemical Industry.
3. Wastes from the Mineral & Metallurgical Industries.
4. Community Wastes.
5. Building materials from Wastes.

It is recognised that waste utilisation leads to resources mobilisation as well as protection f the environment. Research for development of suitable technologies for converting wastes nto useful products has been worked out. *A national coordinating council for waste utilisation nvolving multiple disciplines, with an office of waste utilisation under Department of Science & Technology, is proposed.* It is recognised that R & D in this area would lead to considerable vealth from wastes. For example, Japan Resources Technical Institute (JRTI) sponsors R & D vork relating to waste utilisation in Japan. This has paid rich dividends to the Japanese conomy based on results of projects mapped out for extensive exploitation. The emphasis n this setcor is on development of composting (by natural and mechanical means); design ngineering for Gobar gas plant for economical operation; development of building materials rom mining and agro-industrial wastes; development of valuable chemicals from wastes. Emphasis on Agricultural and Animal Waste Utilisation is placed with detailed planning of R & D efforts for utilisation of wastes of crops, fruits and vegetable processing industries orestry, fisheries and animal wastes. A list of wastes, their present position regarding utilisation n India and R & D work done for each, is also given. A single example of slaughter-house vastes shows that Rs. 29 crores (in terms of products) per year are lost by non-utilisation. For other wastes, the amounts are much larger and need to be investigated in detail to cover all wastes, in a comprehensive manner and action-oriented approach to intensive exploitation

Projects regarding waste utilisation arising out of other NCST Panel are also included f comprehensiveness.

The total R & D for this sector is about Rs. 13.5 crores, with a foreign exchange compone of about 0.6 crores. The programmes envisaged herein would provide employment for abo 1400 scientists and engineers and about 900 technicians.

SUMMARY OF FINANCIAL REQUIREMENTS

1. All India Coordination on Waste Utilisation (Office of Waste Utilisation)	Rs. 0.90 Crore
2. Agricultural and Animal Wastes	Rs. 6.72 Crore
3. Industrial Wastes	Rs. 0.75 Crore
4. Community Wastes	Rs. 2.15 Crore
5. Building Materials from Wastes	Rs. 2.98 Crore
TOTAL	Rs. 13.50 Crore

The projects identified by the various planning groups are as given below:—

Project Index No.	Title	Funds (Rs. in lakhs)
	GROUP 0 : General	
$S_{23}G_0P_1$	Setting up of an All India Council for **Utilisation and Recycling of Wastes**, with Regional Centres/R & D Liason and Extension cells for 5 regions of the country. To be co-ordinated and housed in Deptt. of Science and Technology. **"Office of Waste Utilisation"** in DST proposed. Includes sponsoring of RDD Projects to research and academic institutions.	90.0
	GROUP 1 : Agricultural and animal wastes	
$S_{23}G_1P_1$	(a) Utilisation of waste materials from trees and,	33.64
	(b) Studies on the extractives of wood-Isolation and identification of the extractive of woods for utilisation and chemotoxonomical purposes.	3.50
2	Documentation and dissemination of technical information on the utilisation of agricultural waste products/by-products in itemised form. (Series of reports, Data Sheets, Information Bulletins).	5.00
3	Technology for effective utilisation for Slaughter-House by-products for economic purposes. (Processing of organic manures from animal wastes e.g. leather wastes, hair wastes, bones, blood and meat wastes etc; production of drugs and chemicals).	75.00
4	Reclamation of Lac Wax from Lac effluents	2.00
5	Studies of Various aspects of the production and utilisation of chitosan and allied products from Prawn Shell Wastes, Trash fish, Crap wastes etc. including Pilot Plants.	28.17
6	Studies on the recovery of wool wax of indigenous wools from scour liquor	2.59
7	Development of Research on the Utilisation of the lipid associates and protein-rich seed meals of **Azadircht** Indica and **Salvadora** eleoides (Submitted to the Group on Rural Industries/funded in above group).	—
8	Utilisation of jute sticks for Pulp making (Submitted to the Sub-Group on jute products).	25.30
9	Utilisation of jute mill waste in leather board manufacture.	5.0
10	Utilisation of cotton sticks	3.00
11	R&D in obtaining rayon from cotton linters.	5.0
12	Preparation of compost from cotton dust	5.0
13	Studies on the biogas or cow-dung gas-plant generator to : (i) reduce the cost of iron drum. (ii) to increase the gas production during winter (Budgetted in Sector on Khadi and Village industries. $S_{24}G_2P_9$)	
14	Fuel briquettes from agricultural wastes.	7.5
15	Protein Food from cellulosic Plant Materials.	10.00
16	Utilisation of plant and forest resources to develop products from naturally available polysaccharides.	2.00
17	Survey, cultivation and utilisation of marine algae	13.00
18	Conversion of cellulosic agricultural waste into sugars and subsequent production of yeast (Saccharisation of cellulose)	12.00
19	R&D in utilisation of Arecanut husk for rubberised mattresses and Insulation pads, & feasibility studies on making packing paper on factory basis.	10.0
20	R&D in utilisation of Arecanut leaf sheath for making items like soles and heels for shoes and sandals and gin washers in cotton gin.	5.0
21	R&D in use of choganu liquid of 'Kali' (Arecanut) in the tanning industry	2.0
22	Preservation and storage of cashew apple	2.0
23	R&D in manufacture of tannins from cashew testa	5.0
24	R&D in the use of cashewnut shell liquid in the railways and defence departments as a substitute for imported materials, on a large scale for paints, varnishes.	10.0
25	R&D in making organic acids (citric acid, malic acids etc.) from cotton leaves	5.0

1	2	3
26	R&D for production of starch from mango peels and kernels, which can be used to partly replace wheat atta for making chapatees.	5.0
27	R&D for economic recovery of oil and protein from the peels of oranges and lime .	5.0
28	R&D to prepare protein, cider and vinegar from apple pomace	5.0
29	R&D for recovery of syrup and vinegar from pine apple peels, ears and eyes . .	3.0
30	Recovery of starch and fibre from banana stem for use in textile and paper industry .	5.0
31	Studies for utilisation of wastes from the vegetable canning industries.	10.0
32	R&D in use of frog oil in the treatment of asthma	3.0
33	Preparation of fish meal from shark liver residue and lobster wastes	5.0
34	Investigation on the possible utilisation of waste material from tea gardens for the production of caffeine, food, colour, antioxidants, polyphenols, etc.	6.00
35	Study of the distribution of caffeine in the coffee plant and coffee waste and the possibility of recovery.	2.00
36	Development of methods for extraction and recovery of volatile oils spices, low-grade spices, spice leaves etc. and of sleeresins from spices with special attention to removal of residual solvent.	10.00
37	Utilisation of waste of cellulosic origin in the Viscose Technology in the Textile Industry : (i) Cellulosic pulp waste (ii) Alkali Cellulose waste (iii) Viscose Waste (iv) Godet Waste (v) Testing yarn cord waste from textile testing.	3.25
38	Central of spoilage, improvement of flesh colour and extension of storage life of mango fruit.	4.0
39	Studies on the utilisation of spoiled and incubator rejector eggs & Viscera from dressed poultry.	2.0
40	Bulk isolation of glucagon biological from slaughter-house wastes and regulatory role in carbohydrate metabolism.	2.0
	Total : .	74.0
41	**ICAR Projects (including participation by states)** Development work and field studies in different studies relating to :	
	(i) technological aspects of major and minor oil cakes.	24.0
	(ii) Microbiological decomposition and recycling of rural wastes (See also group 3) .	22.0
	(iii) Utilisation of crop wastes—Food crops, commercial crops, horticultural crops (See projects in this group). (Field Studies only national amount). .	28.0
42	Project on which status reports need to be compiled to assess the present status of technology as a base for formulation of policy decisions by the Government to utilise research results and apply into practice by choosing from various alternatives for production decisions.	
	(a) Utilisation of by-products of rice milling industry and other rice wastes. . .	1.0
	(b) Availability and Utilisation of Non-edible minor oil seeds	
	(c) Utilisation of Agricultural by-products as cattle and poultry feed	
	(d) Economic utilisation of sea weeds	
	(e) Utilisation of fisheries wastes	

N.B. This list does not include projects on utilisation of Agricultural wastes for development of building materials.

$_{23}G_1P_{43}$. **Design-Development-production/Pilot Projects (to be financed based on the Techno-economic feasibility reports)**

1	2	3
(a)	*Activated carbon* from coconut, walnut and apricot shells, arecanut husk, rice husk, saw dust.	Rs. 250 lakhs.
(b)	*Oxalic acid* from saw dust, tobacco waste, pine apple waste, corn cobs.	
(c)	*Furfural* from oat hulls, corn cobs, and stalks, bagasse, groundnut shells, rice husk, sawdust.	
(d)	*Household detergents*, from paddy husk	
(e)	*Pectin and Oil* from the wastes available from the fruit and vegetable processing industries.	
(f)	*Glue-Gelatin, Ossein and Dicalsium phosphate from bones.*	
(g)	*Tannins* from vegetable sources	
(h)	*Paints, varnishes, resins, lacquers, gums* and *lubricating oils* from cashewshell gum, coconut pith, oil sardine.	
(i)	*Nucotine sulphare* from tobacco waste.	
(j)	*Vegetable oils* from Rice bran, tobacco seed, fish, non-edible oilseeds.	
	Total G_1	Rs. 672.00

GROUP 2 : Utilisation of Industrial Wastes

A: Projects Budgetted in this Group

$S_{23}G_2P_1$	Studies on Better Utilisation of Steel Plants Wastes ($S_7G_3P_9$).	5.0
2	Utilisation of Ferro-alloy furnace, gas and fines. ($S_7G_{12}P_3$) Gas of good Calerific value and fines are evolved in the manufacture of Ferro-alloy in electric furnaces irrespective of the type of furnace (semi-closed/open) used. Feasibility studies on the utilisation of top gas and fines are to be carried out.	2.85
3	Recycling of water for industrial uses in certain industries like textiles, paper, petroleum, fertilizers etc. Pilot Plants. Field Studies.	31.0
4	Recovery of fines from Coal washeries and reuse of water.	1.50
5	Recovery of Zinc and Carbon Electrodes from Used dry cells	0.50
6	Development of synthetic resin adhesive from industrial wastes	2.0
7	General surveys on the characteristics and treatment of different industrial wastes and feasibility report thereon.	4.0
8	Utilisation, treatment & disposal of diary waste	3.0
9	Survey of some solid industrial wastes in India	3.0
10	Mechanical compositing of cotton dust from textile mills	3.0
11	Utilisation of coke breeze, blast furnace dust, L.D. dust and mill scale available at steel plants.	5.0
12	Utilisation of Coal ash including extraction of germanium	5.0
13	Utilisation of coal distilation products	5.0
14	Recovery of sulphur from waste-gases and desulphrisarion of fuels (coal and oil)	4.0
	Total G_2	Rs. 75.00

B: Projects Budgetted in other Panels

Index Numbers of the Projects on Industrial Wastes budgetted in the *'Chemical Industry'* panel

$S_5G_1P_{12}$ $S_5G_2P_1$ $S_5G_2P_2$ $S_5G_2P_3$ $S_5G_2P_{10}$, $S_5G_2P_{11}$ $S_5G_3P_1$, $S_5G_3P_8$,
$S_5G_3P_{13}$, $S_5F_4P_{23}$, $S_5G_4P_{24}$ $S_5G_5P_2$;, $S_5G_5P_{17}$;, $S_5G_6P_1$

Numbers of the Projects budgetted in the *Mining, Steel and Metallurgy' panel*

$S_7G_5P_4$, $S_7G_5P_6$, $S_7G_5P_6$, $S_7G_5P_8$, $S_7G_5P_{11}$, $S_7G_5P_{18}$, $S_7G_{10}P_3$,
$S_7G_{14}P_5$;, $S_7G_{15}P_{45}$, $S_7G_{15}P_{89}$.

Projects budgetted in the *'Consumer Industries'* panel

$S_{14}G_3P_{28}$ S_{14} G_3P_{29} $S_{24}G_3P_6$ $S_{24}G_3P_7$ $S_{24}G_7A_1P_7$ $S_{24}G_2P_{34}$

GROUP 3 : Community Wastes

I Projects on Liquid Wastes

$S_{23}G_3P_1$	Degree of treatment and design criteria to be used prior to the recycling or utilisation of sewage with or without dilation on land, have to be developed.	8.00

1	2	3
2	Information on the quality of liquid wastes from rural and urban areas has to be collected to identify the characteristics within a band-width. In collating and collecting fresh information, emphasis should be given to find out the proportion of N, P & K present in the liquid wastes.	2.00
3	To prepare a code of practice for sewage farms indicating their design, size, under-rainage, loading, cropping patterns, health hazards, financial and management aspects, etc.	2.00
4	Data collected on the health status of sewage farm workers as compared to workers where protective measures are implemented and health hazards in the consumption of sewage grown products should be continued.	2.00
5	In view of recycling of treated or partially treated sewage effluents, it is suggested that the following studies be undertaken:	
	(a) Die-away rate of pathogens and enteric viruses in sewage during its treatment by conventional and low cost treatment methods.	5.00
	(b) Travel of pathogens including viruses in ground water and survival of pathogens in sewage irrigated soils.	5.00
	(c) Survival of pathogens during sewage disposal into marine and esturine environments.	5.00
6	The nature and mechanism of development of sewage sickness of soil in sewage farms and the effect on soil fertility has to be studied. The establishment of permanent plots in different type soil regions may have to be considered so as to evaluate long term changes.	10.00
7	The direct use of sewage sludges has to be further studied keeping in view the following aspects : (a) fertiliser value. (b) health aspects' and (c) reduction in the cost of treatment of sewage.	3.00
8	Cultivation of edible fish, using treated sewage effluents, needs to be studied in collaboration with the fisheries department.	2.00
9	Studies on ground water reacharge using treated sewage effluents and a comparative study on the direct use of treated sewage effluent versus unfiltered water for irrigation have to be made.	10.00
10	Role of impounded sewage on its utilisation for irrigation on land and for the development of waste treatment parks has to be looked into.	2.00
11	Development of know-how for the reuse of sewage effluents in urban areas which involves sophisticated tertiary treatment methods such as reverse osmosis, electro-dialysis, slow sand filtration, de-nitrification, carbon absorption etc. depending upon the end use. The know-how for the above techniques has to be developed.	50.00
12	Utilisation of treated sewage to prevent sea water intrusion in coastal areas has to be studied.	10.00
13	Water quality standards for sewage effluents used for different purposes, such as agriculture, fish culture, in industry for process water, green belt, have to be developed.	4.00
14	Development of ecologically balanced liquid waste treatment and utilisation process. (for example: Development of a system for biological decomposition of Organic Waste with built-in garbage chute and toilet.) To cite an example: "CLIVUS" system developed in weden converts human wastes into compost avoiding the need for sewers or large amounts of water.	20.00
	II Projects on solid wastes	
$S_{23}G_3P_{15}$	**Study of health aspects :**	
	(i) In composting: During the composting of refuse (a) with nightsoil and (b) with sludges. The study should look into the possibility of survival of pathogens and parasites as well as chances of transfer of infection to the workers.	5.00
	(ii) Transfer of infection during utilisation of compost.	
16	Health aspects involved in salvaging of refuse during collection and transportation of refuse.	1.00
17	To ensure optimal operation of mechanical composting plants, it is necessary to carry out a cost benefit analysis of the various unit operations and obtain suitable combination for different conditions in India.	5.00
18	Direct application of shreded refuse on such soils, which are not being immediately used, for growing crops. This will reduce the cost of composting. (This process is in use in some western countries).	5.00
19	Evolving new techniques for economic recycling/disposal of soil wastes.	20.00

1	2	3
20	Reclamation of land by improved methods of land-fill elimination of possible health hazards during fulfilling posed by products of decompositions. Assessment of health and environmental hazards during the use of such reclaimed land for cultivation.	5.00
21	Studies on the extent of groundwater pollution by leachates from landfill and control measures against this problem.	5.00
22	Development of solid wastes management models for optimisation of collection, transportation and disposal systems.	10.00
23	Standardisation of analytical techniques in solid wastes analysis; in addition to the standardisation of methods of analysis, attention should be given to such methods which use larger sample and attention should also be directed to standardisation of sampling methods.	10.00
24	Reclamation of manure by composting refuse alongwith digested or raw night soil and cow dung and the health aspects involved therein.	4.00
25	Further studies on cowdung digestion to increase the gas production and to obtain favourable economics of the process.	5.00
	Total G_3	215.00
	GROUP 4 : Building materials from wastes	
G_4P 1	R & D Centre for Utilization of Mineral Wastes as building materials	60.0
2	R & D Centre for Utilization of Agro-Industrial Wastes as building materials (Appendix)	60.0
	A. Projects Requiring Pilot Plant, Development, Design & Engineering.	
3	Lightweight aggregate from Blast furnace Slag	5.0
4	To utilise fly ash for the manufacture of :	
	(i) Portland pozzolana cement	7.5
	(ii) Lightweight aggregate	4.0
	(iii) Lime flyash bricks	10.0
	(iv) Silicate bonded flyash bricks	7.5
5	(i) Hydraulic lime from Carbonate Sludge from Sugar and paper factories . .	2.5
	(ii) Masonry and Cement from Carbonate Sludge and flyash	2.5
6	To utilise Gypsum Waste for the manufacture of :	
	(i) Cement set retarder	5.0
	(ii) Gypsum plaster	
7	Lightweight aggregates from Water Works Silt	12.0
8	Building boards and panels from Agro-Industrial Wastes-Corrugated pulp cement boards from paper wastes (Improved structural configuration) and improved processing).	30.0
	B. Projects Requiring Laboratory Investigations:	
9	Portland blast furnace slag cement and super sulphated cement from Blast furnace Slag.	10.0
10	Cement manufacture from Phosphorous Furnace Slag.	1.75
11	To utilise Carbonate Sludge for the manufacture of:	
	(i) Cement raw material	0.75
	(ii) Component of masonry cement [See item P5(ii)]	0.50
12	Building bricks/expanded blocks for structural purposes/Refractory bricks from Red Mud from Aluminium Industry.	7.0
13	Hydraulic binder from Kiln Dust	2.50
14	Lime bonded bricks from Cyanide Sludge	1.00
15	To utilise Agro-Industrial Waste for the Manufacture of :	
	(i) Bricks from rice husks	0.50
	(ii) Cement from Rice husk . . . Preliminary Studies	4.25
16	Fuel in pressed blocks from Town Garbage	1.25

1	2
17	Utilisation of Basalt Fines for the development and Improvement of Ceramic Building Materials.
18	R& D Projects related to basic work on building materials from wastes
	C Miscellaneous
19	Utilisation of Industrial Wastes—Use of wastes from paper factories (Containing appreciable quantity of lignin), and low quantities sugar content waste for rapid Soil-stabilisation by Chemical methods. Laboratory study of Physico-Chemical changes and their relation to strength and durability-Emphasis on foam formulations (foaming method) for Soil-stabilisation. At present, chemicals such as bitumen, silicates are used as emulsions but require larger quantity of emulsion giving uneconomical end product.
20	Manufacture of non-hydraulic lime & Utilisation of by-products limes from other industries.
21	Development of lime & cement bonded & silicate bounded & hot-pressed units from industrial wastes.
22	Utilisation of slags for Glass, Ceramics and Refractories . . . .
23	Utilisation of electrical steel melting furnace slag (Arc Furnace Slag) from Mini-Steel Plants etc.
	Total G4

CTOR—HOUSING, URBANISATION AND CONSTRUCTION TECHNOLOGY

HOUSING, URBANISATION AND CONSTRUCTION TECHNOLOGY

The National Committee on Science and Technology (NCST) had set up a Panel on sing and Urbanisation in order to effectively apply Science and Technology to satisfy vital al and development needs of the country in the area of built environment and physical ning. The Plan covers Research, Design, Development, Production, Surveys, Information Documentation, Integrated Training Programmes, Education and Manpower back-up, need- rganisational changes and the policies needed to accelerate the civil engineering construction stry. It must be emphasised that unless the extension services are suitably strengthened by ministries and agencies as part of their plan programmes, the fruits of R&D would not bear lts in actual practice in a tradition ridden construction industry (as was realised for Agri- ure). The extension back-up, together with developmental efforts for popularising use of es and standards, that are necessary for getting results and effecting economies through better lication of Science and Technology, are also presented. The Panel is broadly divided into two ups :

(i) Housing and Construction Technology (to cover the Planning, Design, Construction Technology and Maintenance Management); and

(ii) Urbanisation (to cover Rural, Urban and Regional Planning for integrated development including the construction technology infrastructure and the engineering services that are required for the same. This is interlinked with (i) above, for relating housing, transportation, utilities and services in terms of land-use, density and other planning standards).

SECTOR ON HOUSING AND CONSTRUCTION TECHNOLOGY

2. Recognising that construction technology has a major role to play, the Sector on Housing expanded in scope to cover the segment of construction technology relating to Housing, Indus- al and Institutional Buildings, as the hardware technological portions are the same, and since s necessary to view materials, equipment and manpower requirements for the sector as a whole, a comprehensive manner. The sector on Housing and Construction Technology is to be ewed in conjunction with Building Technology, Transportation (Panel 7), Water Resources ctor of Natural Resources (Panel 2), Coastal and Offshore Structures Sector of Marine Resour- s (Panel 17), etc. This sector gives a broad indication of construction R & D requirements r Fuel and Power, Heavy Engineering, and other industries/panels of NCST. The Science d Technology Proposals emanating from these sectors should be viewed in a larger context the building and construction infrastructure required for various ministries in the Centre as ell as in the states. Based on studies made by the Planning Commission relating to the Third ve Year Plan, it has been estimated that about 50 per cent of the overall plan developmental tlays in the public sector alone has been spent in the civil engineering construction sector cluding Irrigation and Power, Transportation, etc. Further, about 25 per cent has been spent the buildings for all the developmental programmes. The figures in the Fourth Five Year an seem to also indicate such a trend. Extrapolating from these, it may be pointed out that out 9,000 crores of rupees of government funds may be spent on the Building Sector alone t of which the expenditure on housing by public funds is an important component. Private ctor housing is also very significant in terms of their outlays as compared to public sector ousing (including industrial townships, colonies, etc.).

3. Thirteen Planning Groups relating to individual functional (or basic) areas, synth areas and back-up areas have been formed by the NCST Panel. In addition, 38 Specialist S groups have been formed as part of the Planning Groups to go into various aspects of the p lem. The list of all the Planning Groups and Sub-groups is given in the Appendix I. E Group or Sub-group consists of scientists, engineers, architects, planners, builders, buil materials' manufacturers, etc., from different organisations representing the entire innova application, user and the technology transfer chain. About 300 professionals from various fessions have been involved in these planning groups.

4. In addition to the working of the Planning Groups, about 350 scientists were invite suggest specific project proposals to identify R&D requirements and innovations in buil techniques. An Expert Group on House Building Technology with special reference to N Construction Techniques, has been functioning since February, 1972. The Expert Group been very useful in the planning process. Besides the above mechanisms, two regional semi of the NCST have been held in February and March 1973 to discuss the approach to Sci and Technology in the field of Housing and Urbanisation in which about 80 persons have p cipated. The feedback from the above seminars are also reflected in the planning process. C sideration of the needed pre-requisites and national coordination in the construction industr being vital was emphasized in the seminars, so as to bring about a rapid and effective "construc revolution" in the country to accelerate development (not only for housing but also for pro ing the infrastructure for industrialisation, and other social services).

Table I shows that the Planning Groups for the Sector on Housing and Construction T nology, and for the Sector on Urbanisation.

TABLE I

I. SECTOR ON HOUSING AND CONSTRUCTION TECHNOLOGY

A. Housing and other building construction: Planning and technology.

*1. Materials of Construction.

*2. Construction Equipment.

*3. Structural Design and Construction Techniques.

*4. Foundations and Foundations Structures.

5. Building Services (Services for specific functions and environmental efficiency building).

6. Urban Housing and Physical Planning.

7. Rural Housing and Community Development (Physical facilities for rural deve ment) (also of interest to Panel 24: Khadi and Village Industries).

*8. Industrial Buildings.

*9. Institutional Buildings (including architecture and physical planning).

*10. Building Practices, Productivity and Management.

*11. Education, Training and Manpower.

*12. Information and Documentation.

*13. Extension Services for the Building Industry.

*Note : Also of interest to 'B'.

onstruction Technology.

NCST Panels on Transportation, Natural Resources (Water Resources), Marine Resources (Ports and Harbours, Offshore Structures) also cover relevant aspects of Construction Technology.

3b. R & D in Structural Engineering.

4a. R & D in Soil Mechanics and Foundation Engineering.

4c. R & D in Earthquake Resistant Design and Earthquake Engineering.

Includes * items given in A above (1, 2, 8, 9, 10, 11, 12, 13) and in II below (2, 3, 4, 5).

ECTOR ON URBANISATION (RURAL, URBAN AND REGIONAL DEVELOPMENT) (Refer also to Panel 18—Environmental Quality).

1. Planning Standards and Planning Methodology for Indian Conditions.
2. Strategy, Planning and Implementation Mechanisms, for physical plans, to get balanced regional development.
3. Planning Group on New Towns (including Industrial Townships).
4. Rapidly Growing Towns (other than metropolitan cities); Slum Improvement.
5. Community Wastes/R&D in Public Health Engineering and Urban Environment. (Refer also to Panel No. 23—Utilisation and Recycling of Wastes, and to Group 5.5 in A above).
6. Socio-technical Aspects of Urbanisation.

5. The deliberations of some of these groups are still in progress and the work is expect- be completed shortly. The interim report giving recommendations of these group are dered in formulating a draft Science and Technology Plan by the NCST for the sector. specific projects, implementing agencies and plan funds required are identified. However s plan, the implementing agency is not shown. Each project is categorised into the follow- tegories by the Planning Groups.

Category C_1: R & D and extension efforts that have immediate applications that can bring results into practice within 2 years, and effect considerable economies.

Category C_2: R & D and extension efforts that can be applied within the Fifth Five Year Plan.

Category C : That can be applied in the long term, preferably within the Sixth Five Year Plan.

6. Construction activities account for about 50 per cent of the total developmental outlays r country, the estimated Fifth Plan expenditure amounting to about Rs. 18,000 crores for onstruction industry from the public sector alone. Also, it is found by many experts, that al formation increases with per capita national income, and that the share of construction rs to be independent of the stage of economic development.

'. The importance of Construction Technology in various sectors of the economy can be ed by looking at the 'Construction Component' of plan outlays. On the basis of the ana- made of the Third Five Year Plan, it is found that in the sector on Agriculture, the Civil eering Construction Component in Agriculture Production was 30% of the development outlays, in Minor Irrigation 70%, in Forestry 27%, in Agriculture Marketing and Ware- ng 60%, and in Community Developments and Panchayats to be about 50% of the total

plan expenditure. In the sector on Power, the component for Thermal Generation was 2
while for Hydro-electric Generation was 65%, and in the Transmission and Distribution
sector as well as in Rural Electrification it was 100%. In the sector on all types of Orga
Industry (heavy, medium) this component was found to be about 30% on an average in
public sector. In the sector on Rural Works, this component was 50%. Thus it is seen
the construction industry pervades through different sectors of the economy, thereby focu
the role of construction technology in planned national development for economic growth.

8. Speedier and economic construction can play a significant part in industrial develop
of the country. A United Nations document on Construction Industry in Developing Count
published in 1969, focusses on the crucial role played by the construction industry in nati
economic plans. "Most economic planning must be aware of the importance of constructio
balanced economic and social development. Yet an examination of more than 40 develop
plans current in the mid-1960s in countries at various levels of economic development re
only limited attention devoted to construction by most of them. Few define targets for const
tion or examine in detail the relationship of construction to other sectors of the economy. T
are a number of reasons for this apparent neglect. The first, which applies particularly
countries in early stages of development, is that construction is difficult to identify; its bound
are not easily defined, as even in the more industrialised countries, it is fragmented amo
large number of small production units inadequately covered by national and regional st
tics".

9. In U.S.S.R. as a part of the policy of GOSSTROY for all industrial buildings (ex
heavy duty steel plant buildings and the like), it is compulsory that prestressed and reinfo
concrete structural products are used instead of steel structures to effect national economies
sidering the availability of the material. This is done effectively by them by earmarking a
tional Research Institute for Industrial Buildings which would coordinate with regional rese
and academic institutions, the results of which are brought out in a form suitable for designers
building components factories, by a suitable "Typification Organisation" attached to the N
nal Research Institute which is charged with the responsibility for research and developmen
wards national goals and objectives. This again is linked up in series with decentralised e
sion organisations throughout the country which have inter-links with design, construction
maintenance agencies. In the context of the conditions in India, it has been found that about 7
of the structural steel can be saved if the pre-cast concrete products industry is appropri
supported by government policy directives which would bar use of structural steel (
type) for such structures. However, for a precast component industry to succeed, there shoul
an assured demand, a continuity of demand and suitable price support up to the stage wh
each factory/or precast concrete workshop (with different levels of industrialisation) could c
to the optimum scale for which it is designed so that it can be economical. These policies
been greatly used in United Kingdom and Sweden. In U.K., there was a preference to pr
concrete products over traditional methods because of the national savings in materials thr
better quality control and increased protection to the construction industry workers by enf
ment of the Factories Act to them, to the extent of 25% above the price of traditional c
truction. At present, about 40% of all the constructions use prefabricated components wh
in Sweden, upto 60% of all the building constructions use prefabrication. However, it
be pointed out that, for the conditions prevalent in our country, it is better to use partial
fabrication with prefabricated roof components and cast-in-situ walling units so that we c
build at a rate which is needed for the demands for the Fifth and ensuing plan periods. La
component in terms of skilled and unskilled labour is of special significance and promotio
technology that would enhance employment potential at the same time recognising constru

ndustry as a scheduled industry so that it can get the benefits like other industries. This is especially important from the view of labour welfare as well as construction safety viewpoints. To fully exploit the rich clay deposits that are available in the Gangetic Plain and certain other parts of the country, it is very important to develop the structural clay products industry at various levels of operation (small scale, medium scale, large scale) to make not only bricks, tiles but also perforated blocks which can be used as a structural part for roof (such as unishell type construction in Poona and the West Coast in South India for single storey construction). It has also been seen that the use of structural clay products in conjunction with concrete and prestressing can give rise to very economical beams and slabs systems using filler blocks of clay for thermal protection. This is an example of how Science and Technology, especially geared to the conditions in the country, can promote the healthy growth of the construction industry. Another example is the technological development of the deformed steel bars in concrete construction as against the traditional plane bars which have brought about tremendous savings of steel to the extent of the production of half a steel plant per annum. This is in addition to the dispersed growth of re-rolling industries which are medium scale and which provide employment and industrial growth.

10. As part of a strategy for a "Construction Revolution", there should be separation between software (design methodology, computer software, planning or design conceptualisation) and production mechanisms (to be suitably scaled towards employment generation, quality control; as suitable to conditions in rural areas, towns/semi-urban towns and metropolitan areas). A country like India which has very high potential for the former, should use the highest level of design and conceptual technology and suitable scaling of production mechanisms. For this to be done effectively, a "Typification Organisation", should be attached to a national laboratory, which will have interaction with production institutions (construction materials, component factories/workshops) and the laboratory, to put the results of research in a usable form through design charts, types with details for implementation. These should be backed up by a widely diffused extension set-up, highly decentralised, like in Agriculture.

11. It is to be emphasized that the present slow progress and the relatively static nature of the construction industry is blocking development, especially of the plans. For the fruition of economic and development plans, the crucial role of the construction industry and the needed improvements and rationalization of the industry is of utmost importance. The present subcritical investment in R&D inputs to the construction industry would also block progress in other critical areas as the construction component of most of our plans is very significant. It has been pointed out by many experts that economic planners must be aware of the importance of construction to balance economic and social development and as such, it is necessary to define targets for construction and examine in detail the relationship of construction to other sectors of the economy, so that the industry has the required inputs for a healthy growth. This would involve far-reaching changes in business of construction, construction practices and management and the administrative procedures which must be geared to promote innovation, speed and conserve national resources, to achieve significant economies.

12. Highlights of Major Programmes Relating to Sector on Housing and Construction Technology.

12.1 A National Coordinating Agency for Construction Industry is suggested with the following tasks: (a) planning, coordination, planned development of inputs and infra-structure for the industry; (b) to execute policy decisions so as to effectively utilise the national resources in terms of men, materials, machinery, techniques and finance; and (c) to provide interlinks between government, R & D and extension agencies; universities, professional bodies, buildings, manufacturers etc. To make sure that the fruits of science and technology and modern management are applied effectively and extensively in the construction industry as a whole, the agency is proposed as an apex multi-ministerial coordinating body. The agency would have a Bureau, working in close liaison with national laboratories and research institutions, to assess innovative techniques in materials, design techniques, equipment and other practices so that once it is approved, these could be applied extensively. Special emphasis on construction materials is necessary. In addition, there would be a need for a Construction Research Board to oversee the R&D aspects relating to the construction industry. Since housing, institutional and industrial buildings are important components of the industrial development plans of the country, it would be necessary to have a board for the building industry as part of the construction coordinating agency. This agency may also have a Building Research Board within itself.

The crucial role of the construction statistics and up-to-date analysis of various components of construction done by various organisations at the centre, state, municipalities, covering various sectors of the economy is found to be necessary. Particularly, at the centre, construction components figure extensively in various other ministries in addition to that in the Ministry of Works & Housing. There is a need for a construction statistics cell as part of the above Apex Organisation to go into details of manpower requirements, training programmes for skilled, semi-skilled, unskilled and supervisory personnel in the construction industry. It is very important to collect statistics regarding public sector and private sector expenditures and data regarding economics of the construction industry in terms of cost of materials, equipment, etc. and the construction component of various sectors of the economy; so that it could serve as a valuable data base for forward planning of the construction industry, both for short-term and long-term goals.

12.2 An important proposal, which would provide employment to a number of highly qualified specialists and technical personnel and at the same time earn a significant amount of foreign exchange, is the setting up of an International Consultancy Bureau in Civil Engineering including structural, highway and public health engineering. This project would be helpful in attracting a number of highly placed Indian engineers, who are working in specialised design firms in foreign countries at project engineering and management levels and above, to be the key-men in addition to the consultants from Indian research laboratories, and academic institutions who have developed high level of software capabilities which are suitable not only for conditions in India but also for the international market. The Bureau may function with considerable autonomy and when it grows in stature, it will be constituted as an independent organisation, if full potential of Indian software expertise can be fruitfully channelled towards above objectives.

12.3 Thrust in S&T in materials of construction. Materials account for about 65 per cent of the total construction costs.

The following areas of major thrust have, therefore, been identified:

(a) Establishment of National Agency or Commission on Materials of Construction. This may form a part of the proposed apex coordinating organisation for construction industry.

(b) Establishment of materials-oriented R&D centres.

(c) An intensive and extensive survey of soils in the country and identification of suitable clays for manufacture of clay products.

(d) An intensive and extensive survey of limestone resources required by the steel, cement and building lime industry in the country and identification of quality and proving of quantity.

(e) An intensive and extensive survey of chrysotile asbestos resources in the country and identification of quality and proving of quantity.

(f) Development of regional resources of ball and china clay for the ceramic industry.

(g) Establishment of chain of preservation and treatment plants for making available secondary species of timber of proven quality.

(h) Whilst R&D is an important component of any S&T Plan, application of existing knowledge to the improvement of quality and performance is an important part of any S&T thrust. The following activities are recommended in this area :

1. Centre for Certification of Fabrication Industry, for performance based on standard practice.
2. Centre for Quality Control of Cement.

(i) The R&D tasks, compiled by individual subgroups, have been examined and grouped for convenience into the following six groups :

A. Raw materials survey and related R&D.
B. R&D in relation to manufacturing processes.
C. R&D in relation to design and development of plant and equipment.
D. R&D in relation to improved products.
E. R&D in relation to new products.
F. Survey of behaviour of materials in existing structures.

12.4. R&D projects relating to construction equipment.

A number of projects relating to the development of fatigue-saving tools; tools to increase
roductivity; development of equipment, plant and machinery for conventional, modern as well
innovative techniques of construction; have been identified. It is recognised that equipment
one of the major handicaps in the construction industry because of lack of adequate research
nd development in this area. It is suggested that a construction equipment RDD Cell/Division
e set up. Universities and IITs have been identified to develop electronic and mechanical
strumentation and testing methods including non-destructive testing and accelerated tests which
ill speed up construction. Detailed indentification of various types of construction equipments
gether with public and private agencies which may be asked to develop these have been identi-
ed in view of the lacuna of sufficient indigenous construction equipment.

12.5. Structural design, construction techniques including different levels of prefabrication.

A number of important projects are formulated which lead to better and optimal utilisation
the scarce materials through proper design techniques; as well as through diversification into
recast products industries (this would help entrepreneurs to set up such industries not only
urban areas but also in suburban areas). Significant emphasis is given on the exploitation of
e local materials such as structural clay products together with concreting and prestressing and
so use of industrial wastes such as fly ash, sugar press-mud, etc. in the development of light-
eight cellular concrete products. Innovative techniques such as electro-thermal type of pres-
essing for high strength of deformed bars could provide tremendous economics in developing
estressed components which are suitable for housing and residential types of construction, as
gainst the usual prestressed concrete which is more suitable for industrial buildings as well as
idges and large span structures. A number of projects relating to the development of industrial
uildings such as factories in view of the scarcity of materials is planned through the "Typifica-
on Organisation" attached to a research laboratory. It is estimated that only about 25 per cent
steel may be necessary than what has been hitherto used if the precast concrete industry is
omoted, both site-oriented as well as factory-oriented.

12.6. Building services.

In this Group, a number of R&D projects relating to services for specific functions and environmental efficiency of buildings with particular reference to the climatic conditions prevalen in various parts of the country, are identified. A significant amount of development and extension work is necessary so as to design better buildings in a scientific manner so that they ar satisfactory from climatic, functional and human comfort viewpoints. A number of projects relating to lighting and ventilation (both natural and various levels of artificial type) are identified It has been pointed out that some of the present standards are not related to the climatic conditions that are prevalent in various parts of the country and are based mostly on the climatic conditions prevalent in United Kingdom. Significant research thrust in this area is necessary, especially when it is related to industrial buildings, because it affects the productivity levels and als the costs in use, unless suitable design of doors, windows and exhaust fans to exploit natura conditions are used. Other R&D projects identified are in the area of sound insulation & thermal environmental services including airconditioning and heating. The latter is geared toward combination of constructional practices together with considerations for tropical climates an also includes the problem relating to cold storage buildings which are very important for agricultural storage. A number of R&D projects relating to fire protection. electrical installation including lightening protection, are identified. R&D projects relating to transportation of men materials and equipment within buildings are also identified in the area of vertical transportatio (lifts and escalators, stairways, with a view to safety, economic cost and its functional performance both at normal times and also at times of fire and power breakdown). The question o water-proof damp protection and pest control is also considered in identifying gaps in researc and development. A very important area is that of plumbing services within buildings for wate supply, sanitation including solid waste refuse disposal. A number of R&D centres in universities and laboratories for rural sanitation and water are also identified as a part of the abov Group.

12.7. Urban housing and physical planning.

In the area of urban housing, there is a proposal for the establishment of a nationa experimental urban housing agency/cell in an established modern construction public secto agency. It is recommended that at least 5 per cent of all government construction during th Fifth Five Year Plan be those which use innovative techniques or at least those projects whic have been tried on an experimental scale through the NBO experimental buildings sponsore projects. Although a revolving fund of Rs. 2.5 crores may be necessary, a sum of Rs. 20 lakh for establishment and Rs. 40 lakhs for prototype construction may be quite adequate for th Fifth Five Year Plan period. Other development projects relate to houses built by individual housing cooperatives, economics of urban housing, incremental type housing programmes ha ing skeleton type of construction but which can be expandable depending upon the increased r sources and the need of the user in a plot which is sufficient for the purpose. A very importa project relates to the survey, evaluation and assessment of waste of building materials and ef ciency of housing units for climate and spatial requirements in different cities of different siz and climatic regions. This will provide very valuable data regarding national policies and bett design practices. There is also a proposal for a low-cost shelter technological break-through suitably designing an All India Competition for Low-Cost Housing. There is a need for R& liaison cells and inter-disciplinary R&D cell in NBO, HUDCO, etc. and Regional Centre Another important project relates to study of sequential type of construction and planning f mass scale housing projects to take advantage of economy of scale. Another important proje that has been identified is that of a large scale experimental construction and field study for pr totype development and ushering of a new technology for urban housing by Hindustan Housi Factory using modern techniques, which can otherwise not be taken up. For housing probler be tackled in a very effective manner, it is necessary that all the aspects (socio-economic and hnical factors) be gone into detail. The gap between demand (requirement) and supply hat is available) at an economic price is so wide that there is a need for the setting up of a using Commission by the Government of India.

12.8. Rural housing and development.

Considerable attention has been paid to the identification of developmental type projects re- ing to rural materials, rural housing and buildings (functional such as cattle sheds, cottage in- stries buildings, community facilities etc.), rural planning and development of model villages least three in each state). Important R&D projects relating to rural water supply and sani- ion are identified in addition to those for roads and development of market towns for a cluster rural areas. These emphasize the role of indigenous development regarding safe water supply om wells and streams such as use of pot chlorinators and development of sanitary privy and ner sewage disposal and drainage facilities. In addition, they would deal with the extension rk relating to compost making, sewage farm, etc. R&D liaison cells with emphasis on de- lopment of indigenous resources to produce rural materials for housing, buildings and commu- y development and using all suitable techniques, are proposed to be set up in 12 regions of country as part of the plan preferably in agricultural universities having engineering de- rtments. These centres are expected to usher in a revolution for the physical environment rural areas and also to develop the building materials industries suitable for their raw materials ailable. In addition, extension work of about 250 housing units per centre, together with 3 odel villages and demonstration buildings of cattle sheds, poultry houses, grain silos, school ildings and health centres, etc. for promotion of new/improved methods and techniques are oposed. Incremental changes in technology with traditional thatching roofing materials would volve the development of timber structures, and economic fire-proofing techniques for which ojects have been identified. Also, development of emulsions for non-erodable plasters and abilising of mud-walls through lime, bitumen and agricultural wastes. Promotion of small-scale medium-scale brick, lime, and other building materials utilising agricultural wastes, have been oposed.

12.9. Industrial and institutional buildings.

A number of projects relating to the development of planning standards and design manuals r various types of institutional buildings have been identified. The scope of RDD efforts is tailed in the back-up sheets in the Appendix. In the area of industrial buildings, because of eir diverse nature and because of the potentiality of using modern techniques and effecting sav- g, a number of R&D projects are being identified. It is proposed that there should be a ouncil for Industrial Buildings which may be a part of the Apex Organisation for the Construc- on Industry. In addition, RDD projects in the field of structural engineering, public health gineering, soil mechanics and foundation engineering, earthquake engineering and construction gineering, have been attempted to cover such wide sectors as power, transportation, water pply projects, industrial development, etc.

12.10. Back-up areas (Building Practices; Productivity and Management; Information and ocumentation; Education, Training and Manpower; Extension Services in the Construction In- istry).

Significant importance is given to the role of extension services in promotion of new techni- ues in the civil engineering construction industry. For example, it is recognised that wide appli- ation of National Building Code of 1970, other Indian Standard Codes of Practice, and results research can achieve significant economies and can change the outlook of the industry. The ole of large scale experimental construction for promotion of new techniques is recognised. The need is felt for having more decentralized dissemination of research information; information standards, codes of practices, training programmes at different levels.

12.11. **R&D** projects relating to civil engineering aspects of steel, heavy industry, pow pipeline, water storage, cooling towers, nuclear reactor vessels, bridges, chimneys, marine str tures, TV tower structures, etc. have also been identified. Furthermore, R&D liaison cells construction agencies, housing boards, and in-service training programmes are also proposed be initiated.

13. *Benefits possible by the implementation of above R & D programmes.*

Based on some studies made on the housing designs by Housing Boards and Metropol Development Authorities, it has been found that rationalisation of space standards and spa planning of individual buildings and housing complexes, together with consideration of functic and climatological efficiency of buildings is possible through appropriate use of the knowledge g ed by research in functional and environmental design of housing. And a very alarming conclu shows that the present designs lead to wastage of critical materials like steel to the order of 2 30 per cent and 50—70 per cent respectively. For this, extensive research, development of de of the 1964 I.S. Code of Practice for Reinforced Concrete Structures. At present, other t making use of mass scale construction for attracting good contractors, the benefits of scale technological innovations have not been realised as yet. As a matter of fact, it is predicted if optimisation techniques are developed and made fully use of in these mass scale constructi it is possible to save materials like cement and steel in these housing complexes by an orde 30 per cent and 50—70 per cent respectively. For this, extensive research, development of de charts and explanatory hand-books through "Typification" and completely decentralised ex sion services, would be necessary. However, these techniques would involve the use of n engineers for inspection and supervision. The economies would be to the extent of 20 to 30 cent of the costs. It is clearly seen that such intensive applications of technology can resu phenomenal economies but must be backed up by very good extension services and nati policy regarding usage of scarce materials. The additional advantage of the R&D efforts pro ed in the plan is the focussing of attention to the use of Science and Technology in the fie traditional materials and methods of construction with a view to improve them significantly. example, it has been possible to design factory or workshop buildings at the Structural Engi ing Research Centre, for as large as 40 feet spans without utilising steel. The technology a compassed in using combination of funicular shells saves a tremendous amount of reinforce as well as cement. For these programmes, education, training and manpower should be ge towards a progressive use of innovative technology. With suitable extension, developme extension services in the field of rural housing and improvement would be necessary to about the fruits of technology to the villages. For this, focus is made in the plan for dev ment of appropriate technologies.

14. *Funding required and implementing agencies.*

As will be seen in the enclosed Table No. 2, the total allocation required for R&D i sectors on Housing and Construction Technology is Rs. 67 crores.

The main implementing agencies for research and development are:

(1) CSIR Laboratories such as CBRI, CPHERI, SERC (Roorkee and Madras) CRII, Delhi, (Industrial Research Institute in cooperation with CSIR), CM RRL (Jorhat), etc. State engineering research laboratories.

(2) Universities, IITs including Agricultural Universities.

(3) National Buildings Organisation, an affiliate of the Ministry of Works and Housing, for work relating to Information, Documentation and Extension Services.

(4) Indian Standards Institution for proper implementation of codes of practice.

It is found that the R&D investments in laboratories and the universities need to have a h larger component than what they have been having in the previous plans because of the ial role of construction, research and development in the national developmental economy. is necessary for the CSIR and the Department of Science and Technology to increase their get allocations and improve mechanisms for the funding and monitoring of research in uni- ities and IIT institutions).

The following table includes the R & D funds for the Fifth Five Year Plan for this Panel.

TABLE NO. 2

Name of the Planning Group	Total Funds in Rs. crores	Remarks
2	3	4
& III. SECTORS ON HOUSING AND CONSTRUCTION TECHNOLOGY		
Materials of Construction	23.50	(Also refer Panels 23 and 24– Waste Utilisation; Khadi & Village Industry).
Construction Equipment	1.50	Excludes NRDC, IMDC funding
Structural Design & Construction Techniques		Includes RDD of Rs. 4.5 crores for Sl. No. 3(a) and 3(b).
(a) Prefabrication including industrialised systems	6.50	
(b) R&D in structural engineering for building & construction industry	5.65	
Foundations & Foundation Structures (Including earthquake engineering)	2.75	
Building Services	4.50	
Urban Housing and Physical Planning	2.47	
Rural Housing & Development	3.80	In addition, projects worth Rs. 2.81 crores identified by this group are budgetted in Panel 24:Khadi & Village Industries
Industrial Buildings	*2.00	Also refer to item 3
Institutional Buildings	*3.00	Also refer to item 3
Building Practices, Productivity and Management	1.56	
Education, Training & Manpower	1.20	
Information and Documentation– Excludes that included as part of National Information System for Science and Technology (for construction 0.75 crore has been asked)	1.00	
Extension Services for Building Industry	4.10	
Miscellaneous– including development work relating to implementation of codes (R&D)	3.47	
Total RDD Components	67.00	Total : Rs. 67 crores
SECTOR ON URBANISATION Rural, Urban and Regional Development. Land Use Surveys; Slums, Rapidly Growing Cities, Market Towns; New Towns, Industrial Townships; Urban Transportation; Water Supply, Sanitation and Public Health Engineering.		Total : Rs. 18 crores
	TOTAL	Rs. 85 CRORES

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*Indicates detailed plans in progress.

SECTOR ON URBANISATION

(*Rural, Urban and Regional Development*)

15. The scope of the Sector on Urbanisation includes rural, urban and regiona planning involving physical planning, infrastructural construction developments, housir transportation, water supply and sanitation, environmental protection, etc. Priority is giv to the R & D relating to Environmental Improvement of Slums and Squatter Colonies, Rur Development, "Deteriorating" Towns, "New" Industrial Towns, Water Supply, Sanitati (including drainage) utilities and other services. It is recognised that in urban and region developments, the cost of hardware is high, as compared to the cost of planning and oth software. It is for this reason that there should be a scientific study of planning standar relating to actual conditions. Further, the planning methodology adopted has to be base on a realistic data base including data relating to hardware such as socio-economic data, ge technical material resource surveys, land use surveys, etc. Housing is to be viewed in tl frame work of physical planning of developments, transportation environmental factors.

16. The problem of urbanisation, especially relating to the conditions in India, is a very complex nature involving a number of disciplines and is very intimately connecte with the socio-economic, cultural and political factors. One of the important inputs in physic planning is the quality of life that the people desire for which the planning standards a to be made. These need to be realistic and flexible enough to cater to the rising aspiratio of the people. Only when these are determined, the use of science and technology, bo in software and hardware, can provide options and technological bases for taking decision It can be said that "Urban and Regional Development is a process that carries a heav scientific and technological load but in which all the levers are of a political-socio-econom nature" ; as has been observed by many experts in the field. It is because of this reaso that the work of the NCST in this sector has been very closely related with the progress mac by the Steering Group on Urban Development, Housing and Water Supply of the Plannir Commission so that they provide the socio-economic inputs to the planning process adopte by the NCST Panel. It is recognised that Science and Technology must act as a catalys to provide immediate and widespread development of appropriate tools for dealing with rura urban and regional problems. However, it has been realised that further progress alor established lines of action or thinking alone, will not be sufficient. Within the year 200 fundamental urban structures, functions and sciences may have to undergo radical change fc which technological support for housing, communication systems, service and transportatio systems, industrial production mechanisms, etc., within the context of the national goals ma have to be developed, (as has been recognised by many experts). This technological innovatio or change will also change our present view of physical and functional urban relationship Because of the present practice of basing the planning standards developed in U.K. and U.S.A leading to low-density developments and high cost of services and infrastructure, as can b seen in the development of New Towns (Capital Industrial, Port Towns, etc.), ther is a need to have realistic planning standards to take care of the realistic socio-economi conditions in this country. Therefore, there is a need for development of rational urban plannin methods employing urban structuring techniques, evaluating planning standards; also, there is a nee for development authorities at various levels and a need to foster innovations through competitions design developmental contracts on actual urban problems by both public and private professiona forming inter-disciplinary teams. They would participate in study, design of urban area including problems of squatters and environmental improvement of slums. It is generall recognised that the migration from rural areas to urban areas may also be carefully checke by a rational strategy for development of rural areas, creating suitable employment opportu nities, and development of industries and market towns for an aggregate of villages, i

ion to strengthening the agricultural service base for ushering in the "green revolution". role of market towns in this process needs to be further developed taking actual case ies into consideration and it may act as a deterrent to growing urbanisation trends if village- stries and agriculture flourish. This would impede the world-wide observed trend of ation from rural areas to nearby towns and cities.

7. Two brain-storming sessions were convened by the NCST Panel and in these sessions, 45 erts participated and presented papers. Arising out of these discussions, the proposals pendix 2) were undertaken, after screening by a Group. As a result of the discussions the Screening Group to evaluate project proposals relating to urbanisation, roup is being formed to go into the question of planning standards for Towns. This group would assess the requirements of R&D based on survey and analysis existing New Towns that have come up in the past 25 years to be undertaken different agencies to be identified by the Group. This would provide a good R & D base realistic planning standards suitable for Indian conditions so that the new industrial towns are proposed in the Fifth, Sixth and ensuing Plans could be developed in an integrated nner to take care of expansion at the fringes of the city causing "disastrous slums" (like Benacheti Area around Durgapur) and effect considerable economies. At the same time, listic planning standards consistent with the costs of infrastructural development and ctional performance would lead to tremendous economies in our steel towns, other industrial ns, capital towns, etc.

18. From the feedback of about 80 scientists, engineers, architects and planners from the Regional Seminars of the NCST relating to Housing and Urbanisation held in Bombay Calcutta to discuss the urbanisation problems of their regions, a number recommendations have been formulated which are shown in the list of R&D projects.

19. The working of the Sector on Urbanisation will be linked with the NCST Panels on ansportation and Environmental Quality (Pollution Control and Environmental Improvement). dition, NCST Panel 23 on Utilisation and Recycling of Wastes in integrated with the work of Sector on Urbanisation. For example, the Planning Group on Community Wastes, deals with blems of utilisation and treatment of urban and rural wastes. In addition, the group would pare a detailed S&T Plan relating to R&D requirement for water supply and sanitation. One the specialist Sub-groups on Building Services relating to refuse disposals, with respect to ildings, has identified a number of problems relating to environmental service aspects of build- s and cities.

20. Based on the discussions of the meeting of the Steering Group of the Planning mmission on Urban Development, etc., NCST had invited identification of broad R&D ojects and extension services in urban and regional Development, especially urban services d infra-structure, for the Fifth Five Year Plan based on socio-economic objectives laid down the Planning Commission for a sectoral allocation of about Rs. 2200 crores. This letter was dressed to 200 specialists in multiple disciplines relating to the above topic. Based on the ove feedback, a number of projects have been identified which are given in the list of ojects. The salient points of some of the major thrust proposals having high priority are given the annexure. The projects are divided into 6 categories as shown in Table 1.

21. Although a number of projects have been received, many of them R&D oriented hile some of them are training and management oriented; there is an emphasis on action- iented design development projects by planning schools, private professionals, Town and

Country Planning Organisation, New Delhi; Office of Environmental Planning and Coordination, New Delhi and State Planning Organisations. However, it is felt that there is a need fo a National Council to carry out or sponsor research, development, specialised teaching, training programmes in integrated rural, urban and regional development, in which number of disciplines relating to various aspects of the problem are synthesised by a systemati approach. This will involve considerable change in the present single discipline centres house in engineering colleges/economics departments/geography departments/architecture depar ments/management institutes. This is needed also to provide a base for rational decision making and to provide options to the government for choice on living environments. Sinc specialised training in integrated urban development is a tremendous gap to be bridged, a least four Urban Systems Centres with planning, architecture, engineering, social sciences economics, management are proposed to be developed in institutions which have the potentia for such integrated programmes.

22. Details of projects relating to Urbanisation are shown in the back-up sheets. The R&D programmes from TCPO, urban development authorities, academic institutions (School of Plannin and Architecture, Delhi, IITs Kanpur, Bombay; Urban Systems Centre of NITIE, Tata Institute o Social Sciences, etc.), other government agencies, private sector including practising professional are given. R&D projects from Indian Institute of Town Planners and from Indian Council of Socia Science Research are expected shortly.

23. A total sum of Rs. 18.0 crores is required for carrying out R&D extension service and training programmes relating to the Sector or Urbanisation. Recognising the need fo data base not only for the construction industry but also for rural, urban and regional plannin and development, it is planned as a part of the National Information System for Science an Technology, which has been proposed by the Department of Science and Technology.

24. *Highlights of Major Programmes Relating to Sector on Urbanisation.*

(1) Setting up of a National Research Board for Human Settlement and Physical Environment is identified as a matter for top priority in view of the fact that there is no single research institute to tackle programmes of physical environment, rural, urba and regional infrastructures; and the quality of life, basis for economic, industria and human development.

(2) Setting up or strengthening of an existing institute so as to provide a base for the creation of a National Research Institute for integrated rural, urban and regional development, in an integrated manner with planning, engineering, systems and management as the core and specialisation in various social sciences, engineering, architecture and planning, management, economics, demography; synthesis-oriented cenrtes for undertaking pproblem-oriented research on actual problems.

(3) Data base (techno-economic-social) for urban planning and regional development.

(4) Specialised training centres for urban engineering and management.

(5) Environmental improvement of slums and squatters' colonies in metropolitan areas.

(6) R&D towards identification and development of market towns for aggregate of villages.

(7) R&D in public health engineering.—Water supply (rural and urban), drainage, sanitation (sewerage, air and water pollution). Setting up of R&D liaison cells in

Central Public Health and Environmental Engineering Organisation. Creation of five centres for carrying out RDD and extension work relating to rural water supply and sanitation.

(8) Setting up of a Centre for Urban Transportation and Road Safety as a part of CRRI and in cooperation with NIDC.

(9) Development of types of urban planning models suitable for Indian conditions and their application of actual case studies of cities.

   (a) Land use planning model.
   (b) Econometric model.
   (c) Optimum distribution of uses along a given alignment to minimise travel costs.
   (d) Development of regional planning model.

(10) Development of planning standards and planning criteria especially relating to density, standards, land use intensity factors for new towns or industrial townships so as to reduce the excessive cost of urban infrastructural services and also a coordinated approach to the peripheral slum developments around the new towns.

(11) R & D towards "Problematic" Cities which have a rapidly decreasing environment leading to high social costs. Developmental contracts for nine different urban areas have been proposed for above:

Kanpur, Poona, Ludhiana, Vijayawada-Guntur-Tenali Cluster, Indore-Ujjain Cluster, Surat or Rajkot-Jamnagar Cluster, Bhopal, Hubli-Dharwar Cluster, Jabalpur, Visakhapatnam, Salem-Nagpur, New Bombay Twin City, Auroville.

(12) Socio-economic studies relating to urban and regional developments (Housing, Transport, Densities, Tall Buildings).

(13) Land use Surveys for rural, urban and regional development all over the country, to be undertaken by TCPO in cooperation with State TCPOs and the Ministry of Works & Housing, so as to form a base for urban growth strategy and delineation of focal points for growth and industrial development, and planning for the same with respect to these developments and the needed services.

(14) Integrated planning systems (urban design approach) taken as criteria for urban renewal, redevelopment, rehabilitation programmes.

(15) Identification of rapidly developing cities (other than metropolitan centres) which might have disastrous consequences in the near future, and to formulate specific integrated urban development plans for the Fifth Five Year Plan. The criteria used for the analysis are:

   (1) Decaying environment, decaying of urban services, slums, poor quality of life;
   (2) High rates of population growth;
   (3) Economic base;
   (4) Cluster of cities, regionalisation;
   (5) Hinterland providing scope for growth;
   (6) Economically backward areas/regions; and
   (7) Model cities using innovative concepts.

APPENDIX 1

LIST OF PLANNING GROUPS AND SUB-GROUPS

Sector on Housing and Construction Technology

DIVIDUAL AREAS

HCT)—1 : *Materials of Construction.*

Specialist Sub-groups:

1. Soils & Soil Products.
2. Rocks & Stones.
3. Limes & Lime Products.
4. Cement and Concretes.
5. Metals and Metal Products.
6. Asbestos & Asbestos Products.
7. Gypsum and Gypsum Products.
8. Timber and Timber Products.
9. Plastic and Plastic Products.
10. Tar and Bitumen.
11. Glass & Ceramics.
12. Building Materials from Wastes. (Projects budgetted in Sector on Utilisation and Recycling for Wastes.
13. Materials for special functions.
14. Rural Materials. (Projects budgetted in Sector on Utilisation and Recycling of Wastes).

HCT)—2: *Construction Equipment.*

Specialist Sub-groups :

Equipment for—

1. Site clearance, Excavation & Foundations.
2. Conventional Buildings.
3. Semi-Prefabrication.
4. Prefabrication.
5. Transportation & Materials handling.

HCT)—3 : *Structural Design and Construction Techniques including Prefabrication.*

Specialist Sub-groups:

1. Prefabrication including Industrialised Systems of Buildings.
2. Structural Design of Buildings (part of R&D Plan is Structural Engineering for Construction Industry).

HCT)—4: *Foundations and Foundation Structures, (Includes Soil Mechanics and Foundation Engineering), Earthquake Resistant Building Design.*

ialist Sub-groups:

1. Soil Mechanics & Foundation Engineering for Buildings.
2. Design & Construction of Foundation Structures (including Machine Foundations)
3. Earthquake Resistant Design in Housing & other Buildings, including Industrial Buildings, Tall Buildings.

15 (HCT)—5: *Building Services for specific functions and Environmental Efficiency*
Buildings

Specialist Sub-groups:

1. Lighting & Ventilation (Natural & Artificial).
2. Acoustics & Sound Insulation (including partition & architectural false ceiling).
3. Thermal Environmental Services (including air conditioning & heating, cold stora buildings & buildings for tropical climates).
4. Fire Protection of Buildings.
5. Plumbing (Water Supply & Sanitation), other Solid Wastes Refuse Disposal Services.
6. Electical Installation (including lightening protection).
7. Vertical Transportation, Lifts and Escalators, Stairways (transportation of men, ma rial & equipment within buildings).
8. Waterproofing, Damp Protection & Pest Control.

II. SYNTHESIS AREAS

15 (HCT)—6 : *Urban Housing and Physical Planning.*

15 (HCT)—7: *Rural Housing & Development (Physical Facilities for Rural Developme*
(See also item 1.14, 5.5)

15 (HCT)—8 : *Industrial Buildings.*

15 (HCT)—9 : *Institutional (including Functional) Buildings.*

15 (HCT)—10: *Building Practices, Productivity and Management.*

Specialist Sub-groups :

1. Buildings Practices (including construction practices).
2. Productivity.
3. Construction Management.

III. BACK UP AREAS

15 (HCT)—11: *Education, Training and Manpower.*

Specialised Sub-groups :

1. Education in Building Technology.
2. Training.
3. Manpower.

15 (HCT)—12 : *Information and Documentation.*
(Also refer to Proposals).

15 (HCT)—13 : *Extension Services for the Building Industry.*

15 (HCT)—14 : *Miscellaneous Projects.*

APPENDIX II

DETAILS OF THE RDD PROJECTS IDENTIFIED BY VARIOUS PLANNING GROUPS

Sector on Housing and Construction Technology

oject ex No.	Title of the Project	Financial outlay in (Rs. lakhs)
	(2)	(3)
	G_0: Interlinks in Construction Industry	
G_0P_1	Setting up of an Apex Coordinating Agency for Construction Industry. (Civil Engineering Construction)...... Multi-ministerial Coordination. (Project $S_{15}G_1A_0P_1$ may be a part of this body). See Appendix 3 for details. *Notional Sum of Rs. 100 lakhs in addition to item $S_{15}G_1A_0P_1$.	100.0*
2	Setting up of a Construction Industry Research Board with participation of government, private builders, manufacturers and professionals with 50:50 participation by government and industry (may be part of $S_{15}G_0P_1$). Sponsoring of R & D work relating to problems of construction industry. @Notional Sum of Rs. 50 lakhs as government contribution.	50.0@
	Total G_0	150.0
	G_1A_0: Materials of Construction	
$G_1A_0P_1$	**National Agency or Commission for Materials of Construction**	100.0
2	**Demonstration-cum-Training Units for Production of New and Improved Building Materials Including Pilot Plants** (Identified by Group No. 13-Extension Services in the Building Industries)	500.0
3	**Research Design Development Relating to the Proposed Building Materials Development Corporation** (NBO-Ministry of Works and Housing). (Plants for production of new and substitute materials amounting to Rs. 30 crores are proposed by the Ministry for the Fifth Five Year Plan)	
4	R & D on basic studies relating to science of construction materials. R & D relating to materials for architectural applications (See subgroup 13). Technological research on construction materials in universities, IIT's, IISc. etc.	50.0
	Total G_1A_0	650.0
	G_1A_1 : Soil and Soil Products**	
G_1A_1P 1	R & D Centre for strengthening the infrastructures for Clay Products including Structural Clay Products.	15.0
2	Survey and identification of brick making clays in the country.	10.0
3	Modernization of brick kilns. Thermal efficiency-fuel saving.	5.0
4	Training of technical personnel for manning semi-mechanical and fully mechanised brick plants.	10.0
5	Development of indigenous equipment for shaping, drying and firing bricks. . . .	15.0
6	Re-orientation of the cottage-scale brick industry into a technology based industry and operating round the year. (Refer also to Project $S_{15}G_1A_0P_2$)	20.0
7	R & D on various factors such as strength, durability of brick masonry including tall buildings, using engineered brick masonry; Reinforced Brick Masonry for Gangetic plain; earthquakes resistant design for variety of bricks and mortars available in all regions of the country.	25.0
8	Strength, durability and thermal behaviour of hollow clay bricks including those for roofs and walls; Hollow Clay tiles+Prestressed concrete components.	10.0
9	Soil Stabilisation Materials Research including application oriented research. . .	30.0
	Total G_1A_1	140.0

**Soil Mechanics aspects dealt in group 4

(1)	(2)	(3)
	G_1A_2 : Rocks and Stones	
$S_{15}G_1A_2P$ 1	Survey of Materials Potentiality for Rocks and Stones, and Rocks for Construction Materials, in various regions of the country, for quality and quantity. Synthesis of existing information to prepare *Aggregate map of India*. (See also item P_4 below) . .	2
2	Exploitation of unconventional raw materials such as anorthosites, alumitic rocks, phosphorites and diatomites.	5
3	Conversion of basic rocks into cast stones for special purposes	5
4	Preparation of standard data sheets for building stones-field survey, sampling and testing.	10
5	Evolution of classification system for rocks for engineering purposes	3
6	Development of test procedures for evaluating rock properties for civil engineering uses.	
7	Study of deleterious aggregates in various parts of the country. Geo-Chemical studies for studying suitability in concretes.	
	Total G_1A_2	51
	G_1A_3 : Lime and Lime Products	
$S_{15}G_1A_3P_1$	R & D Centre for strengthening the infrastructures for Lime and Lime Products in Civil Engineering Industry.	2
	Raw Materials Survey and Related R & D	
2	R & D Work relating to survey of limestone resources required by the steel, cement and building lime industry in the country and identification of quality and proving of quantity. (of interest to sub-group 4 also) (Rs. 200 lakhs are required for complete survey of limestone, as part of GSI plan/non-plan expenditure)	2
3	Development of centres for the manufacture of hydrated lime and lime pozzolana in different parts of the country to cut down costs of transportation.	
	R & D in Relation to Design and Development of Plant and Equipment	
4	Development of 100 tonne dry lime kiln (Buy design from Hungary/Germany and work out details).	3
5	Development of technology and equipment for the manufacture of high calcium/high magnesium hydraulic limes	
	R & D in Relation to New Products	
6	Development of alternative fuels for lime kilns	5
	TOTAL G_1A_3	9
	G_1A_4 : Cements and Concretes	
$S_{15}G_1A_4P_1$	Centre for quality control of cement	1
2	Centre for inventory and quality appraisal of aggregates in various parts of country, for concretes (Survey of Concrete Aggregates) (See Sub-group 2 also)	1
	R & D In Relation to Manufacturing Processes	
3	Improvements in the methods of quarrying in cement industry.	
4	Improvement in fuel economy in the manufacture of cement	
5	Evolving methods for the control, collection and recycling of dust in the manufacture of cement and utilization for other purposes	4
6	Fluidised bed & precalcination methods of manufacturing cement. Development of advanced technology for manufacture of cement	19

(1)	(2)	(3)
7	Utilization of naturally occurring but relatively lower grades of raw materials in the manufacture of cement	8.0
8	Development of rapid methods of analysis of cements, cement products and their raw materials.	3.0
9	Standardisation of improved methods of testing cement, concrete and related materials and quality control techniques.	2.0
10	Improvement in efficiency in size reduction in the manufacture of cement	5.0
	R & D In Relation to Design and Development of Plant and Equipment	
11	Improvement in the life of refractory lining in cement kilns	10.0
12	Improvements in the methods of packaging cement	4.0
13	Design and development of experimental cement plant, for laboratory research and development of improved methods of manufacture and for development of cements for special purposes e.g. oilwell, slag, supersulfated, shrinkage compensation, high early strength cement etc. (2 Ton per day experimental plant with requisite instrumentation to study process variables)	25.0
	R & D In Relation to Improved Products	
14	Reduction in the incidence of corrosion of steel in concrete of special compositions and exposed to aggressive environments.	3.0
15	Development of dependable non-destructive methods of testing concrete	12.0
16	Development of methods of design and manufacture of high strength concrete	2.0
17	Development of ready mixed concrete in conditions as prevailing in India. (Refer $S_{15} G_1 A_0P_2$).	30.0
18	Development of heavy weight concrete	2.0
19	Development of light weight concrete	7.0
20	Development of gap-graded concrete	4.0
21	Development of heat insulating and heat resistant and refractory concrete	5.0
22	Ferro cement for various applications (Silos, Boats etc.)	5.0
23	Soil cement and applications	2.0
24	Development of protective coating for concrete for resistance against aggressive agencies	10.0
25	Development of concrete for resisting aggressive environments	5.0
26	Development of methods of extreme weather concreting techniques	2.0
	R & D In Relation to New Products	
27	Development of oil well cement (Refer Sector on Natural Resources)	8.0
28	Development of shrinkage—compensating and expansive cement	10.0
29	Development of high strength cement	4.0
30	Development of architectural concrete finishes	4.0
31	Development of cellular concretes using flyash for various parts of country	5.0
32	Development of polymer (including epoxy and latex) concrete, mortar and ground	20.0
33	Development of fibre reinforced concrete; Basic material proportics, Impact, Fatigue . Applications (Refer to Group 3.1, 3.2.)	15.0
34	Development of admixtures for concrete	10.0
	Survey of Behaviour of Materials in Existing Structures	
35	Survey of behaviour of concrete in marine structures	8.0
36	Survey of behaviour of concrete exposed to aggressive environments in industrial structures.	5.0
	TOTAL G_1A_4	511.0

1	2	3
	G_1A_5 : Metals and Metal Products	
$S_{15}G_1A_5P_1$	R & D Centre for strengthening the infrastructures for Steel and other Metal Structures .	60.
2	R & D Centre for Quality Control and Centre for Certification of Fabrication Industry for performance, based on standard practice	10.
	R & D in relation to design and development of plant and equipment	
3	Investigations on fabrications aspects of steel structures including shop and site fabrication	10.
4	Investigations relating to impact factors on crane gantries	10.
5	Investigations on bracing in large steel structures	5
	R & D in Relation to Improved Products	
6	Investigations connected with hot rolled sections, various design considerations connected with beam and column design, composite construction. (Refer Group 3.2)	20.
7	Investigations relating to reinforcement (deformed bars)	5.
8	Investigations relating to design of crane rails	2.
9	R & D Centre for strengthening the infrastructure for Improved use of Aluminium in Civil Engineering Structures and components.	10.
	R & D in Relation to New Products	
10	New innovations in design such as castellated sections, open web sections, tubular sections, light gauge section etc.	10.
11	Use of aluminium for newer applications in civil construction	10
	Survey of Behaviour of Materials in Existing Structures	
12	Survey of performance of steel exposed to aggressive environments in industrial structures	3.
	Total G_1A_5	155.
	G_1A_6: Asbestos & Asbestos Products	
$S_1G_1A_6P_1$	R & D Centre for Asbestos Products	60.
2	RDD relating to survey of Crysolate asbestos and identification of quality and proving of Quantity. (A sum of Rs. 400 lakhs is required for carrying out the survey, which may be met with normal or plans expenditure of IBM, GSI)	40
3	Development of A.C. Cement Products (pipes, corrugated sheets) using indigenous Amphibole group of asbestos.	20
	Total G_1A_6	120
	G_1A_7 : Gypsum and Gypsum Products	
$S_{15}G_1A_7P_1$	R & D Centre for Gypsum and Gypsum Products (Refer appendix 3 for details of projects)	25
	Total G_1A_7	25

1	2	3
	G$_1$A$_8$: Timber and Timber Products	
G$_1$A$_8$P$_1$	R & D Centre for strengthening the infrastructures for Wood Science and construction applications (May be part of proposed institute for Wood Science. Refer Sector on **Natural Resources, sector on Wood Resources**).	80.0
2	Preparation of design data for plywood, hardboard, particle board, saw-milling and wood-working machinery.	13.0
3	Development of grading techniques for logs and converted timber	6.0
4	Development of non-destructive tests for strength, decay, insect attack and quality control of timber and timber products.	20.5
5	Development of glue-lam structural units from hardwoods.	7.0
6	Development of wood-plastic composites	4.5
7	Development of particle boards and suitable adhesives for tropical climate . . .	12.0
8	Development of wood cement blocks, panels and slabs for building	18.0
9	**Development of timber engineering techniques**	7.0
10	Utilisation of wood based panels in prefabricated building components . . .	6.0
11	Establishment of Indian Institute of Wood Science (See Panel on Natural Resources (also P$_1$)	..
12	Creation of Timber Development Corporation with regional depots for processed timbers. To undertake both extension work as well as supply ready processed timber. (See Panel on Natural Resources)	..
	Total G$_1$A$_8$	**174.0**
	G$_1$ A$_9$: Plastic & Plastic Products	
$_1$A$_9$P$_1$	R & D Centres for strengthening the infrastructures for Plastic Producer for Construction industry (including Sponsoring of RDD Project to Universities, IIT's, NBO, Shriram Institute and other research institutes. Sponsoring of following Projects (See Appendix 3)	250.0
	R & D in Relation to Improved Products	
2	Development of large diameter plastic pipes for higher working pressures, tropical temperatures and exposed locations (10 lakhs)	..
3	Development of polycarbonates and ABS alloys in water meter (impeller) and pumps (8 lakhs)	..
	R & D in Relation to New Products	
4	Development of glass fibre reinforced plastics and glass reinforced polymers for structural applications. (Polythylene, Polypropylene and PVC, Polystyrene and Polycarbonates). . (8 lakhs)	—
5	Development of wood flour filled PVC composites for door ad window frames . (2 lakhs)	..
6	Development of structural plastic foam for structural use (8 lakhs)	..
	General	
7	Studies on weathering of rigid PVC (1 lakh).	..
8	Correlation of field trials with accelerated weathering tests of Plastics such as Teflon for bridges etc. (1.5 lakhs)	..
	Total G$_1$A$_9$	250.00

1	2	3
	G_1A_{10} : Tar and Bitumen Products	
$S_{15}G_1A_{10}P_1$	R & D Centre for strengthening the infrastructures for Tar and Bitumen Products (See Appendix 3 for P_1 to P_{11})	10
2	Bitumen Emulsions	3
3	Blown Bitumen	4
4	Modified Binders	4
5	Bituminous Compounds	5
6	Low Temperature Tar	6
7	Waxy Bitumen	6
8	Grade of Bitumen	3
9	Bitumen in Hydraulics (Canals, dams and other irrigation and power projects)	4
10	Bitumen Aggregate compositions	6
11	Pavement Layer System	9
12	Asphalt Concrete with asbestes fibres for improved ductility of roads: Laboratory & field tests	10
13	Tar and Bitumen Products for water proofing of buildings, preventing water leakage in development of canals. (See group 5)	[illegible]
14	Asphaltic corrugated Roofing materials-Materials research and optimum structural configuration, for Indian Conditions. Techno-Economic Conditions	10
	TOTAL G_1A_{10}	80
	G_1A_{11} : Glass & Ceramics	
$S_{15}G_1A_{11}P_1$	R & D Centre for Glass & Ceramics building products (including setting of regional R & D liaison cells). See Appendix 3.	30
2	**R & D on Raw Materials Survey** Development of Regional resources of ball and china clay for ceramic industry	10
3	**R & D in relation to manufacturing process** Development of fast firing techniques for glass & ceramic industries	10
4	**R & D in relation to Improved Products** Development of low expansion glazes	10
5	Development of lead-boron free glaze and low zinc glass	10
6	Behaviour of Glass, use for thermal conduction especially for airconditioned buildings, cold storage buildings (2 layers of glass with vacuum in between)	2
7	Behaviour of Glass Panel for sonic booms aircraft Development Design Criteria	3
8	Indigenous Development of glass fibres alkali resistant glass. Applications to composite materials with cement plastics.	5
9	Development of steel fibre reinforced glass for various applications	3
	TOTAL G_1A_{11}	83

G_1A_{12} : Building materials from wastes. Projects on this subject are budgetted in Sector on Utilisation and Recycling of wastes (Group no. 4). However, this planning sub-group functioned under the Group "Materials of Construction".

1	2	3
	G_1 A_{13} : Materials for Special Functions	
$_{15}G_1A_{13}P_1$	Development of materials for sound insulation and thermal protection	5.00
2	Development of materials for waterproofing and damp-proofing	2.00
3	Development of materials for architectural treatments	5.00
4	Development of coatings to improve durability of brick walls, plasters etc. . . .	2.00
5	Development of Fire-Proofing Coatings and fire retarders on materials and components (Refer Group 5)	—
6	Development of materials for expansion joints	1.00
7	Development of materials for roof system for housing, for integrated design, for structural, thermal, waterproofing purposes. (see 5.8)	5.00
	TOTAL G_1 A_{13}	20.00

G_1A_{14} : **Rural Materials***

RDD projects relating to development of rural materials industries to be coordinated/sponsored by KVIC of Ministry of Industrial Development, and NBO (MWH)

*Budgetted in Sector on Khadi and Village Industries No. 24 (Part of programmes transferred from Sector No. 15 to 24) : 13 RDD and Pilot Plant Projects indentified by the above sub-group are listed under $S_{24}G_3A_1$ for a total of Rs. 219 lakhs

GRAND TOTAL for all Sub-groups (1 to 14) on Materials of Construction, that is budgetted in Sector on Housing, Urbanisation and Construction Technology.
(Sum of G_1A_0 to G_1A_{14})

Total G_1 : **Rs. 2350 LAKHS**

G_2 : **Construction Equipment**

1	2	3
$S_{15}G_2A_0$	Setting up of Research Design and Development Cells on Construction tools, equipment, plants & process in existing research laboratories, for the following (Detailed RDD projects given under sub-groups A_1 to A_5)	
$S_{15}G_2A_0P_1$	Light construction equipment including fatigue reducing tools and for increasing productivity in building processes.	40.0
2	Medium and heavy type construction equipment. Full fledged division for construction equipment in CMERI (MERADO) on a continuing basis.	45.0
3	Construction equipment for partial prefabrication and development of industrialised systems of buildings. Light and medium range equipments.	40.0
4	Design and RDD towards solving of high altitude problems connected with construction equipment and methods, of strategic significance.	—
5	Development of light testing equipment, construction tools and equipment in academic institutions having strong civil, mechanical, electrical, electronics, instrumentation engineering departments. (At least 5 Centres)	25.0
A_1P*	Open sponsored RDD Projects relating to construction equipment for site clearance, excavation and foundations. (13 Projects identified). Development contracts to be given to selected Private and Public Sector institutions in addition to RDD Cells. (Also refer to $S_{15}G_2A_0P_1$ and P_2) Details given in Appendix 3.	—
A_2P*	Open sponsored RDD Projects (Development contracts) relating to construction equipment for conventional building methods for superstructure. (6 projects identified) Also refer to $S_{15}G_2A_0P_1$ above. Details given in Appendix 3.	—

1	2	3
A_3P*	Open sponsored RDD Projects (Development Contracts) relating to equipment for partial prefabrication-production.fabrication equipment, handling and erection equipment, accessories and aids for construction; testing and control equipment. (45 Projects identified) Also Refer to $S_{15}G_2A_0P_3$. (Details given in Appendix 3)	—
A_4P*	ibid. for Full Prefabrication (Large Panel, Box Prefabrication of buildings). Manufacturing Equipment, Transportation and Handling Equipment, Equipment for Erection and Assembly (12 Projects identified. Some are common with sub-group 4). (Details given in Appendix 3)	—
A_5P*	Open Sponsored RDD Projects relating to Transportation and Materials Handling Equipment for Construction (45 Projects identified. Some are common with sub-groups A_1 to A_4) (Details given in Appendix 3).	—
	Total G_2	150.0

G_3 : Structural Design and Construction Techniques

G_3 A_1 : Prefabication and Industrialized Systems of Building

(Also of relevance to Group 8 : Industrial Buidlings).

A. Areas of Major Thrust.

$S_{15}G_3A_1P_1$.1	Setting up an Apex Research Organization to play the pivotal role in introducing prefabrication and industrialized building systems, framing criteria and assessing systems and coordinating all the R&D projects to be undertaken in these fields.	205.0
1.2	Setting up five regional centres of the Apex Research Organization. (Research, design, development and introduction of industrialised building systems for mass housing and industrial buildings).	
2	Setting up of a Typification Organization for repetitive industrial, institutional and residential buildings. (See details in Appendix 3) (Optimal structural design of typical components).	85.0
3.1	Development work for Extension work on prefabrication (Refer P_1, also)	11.0
3.2	Setting up of 20 extension-cum-demonstration-cum-training centres in various parts of the country for extension of R&D results and liaison with industry. (Refer Group 13 Project 3); also Project 6.18 in this list; also Project 2 of Group on Mateials of Construction A total of about 200 lakhs required for 20 extension centers.	

B. Projects of High Priority

4	In-house R&D in factories manufacturing precast building components.	100.0
5	**Development of partially prefabricated systems and industrilized buliding.**	**70.0**
5.1	Development of standardised and optimised flooring systems such as channel units, hollow cored prestressed slabs, funicular shells. (15 Lakhs)	
5.2	Development of design principles and assessing behaviour of precast units made of fly ash concrete. (6 lakhs.)	
5.3	Development of component designs and prefab system using cellular concrete and studies on strength, durability, and economy. (18 Lakhs)	
5.4	Studies on structural hollow clay blocks and other units including prestressed composite ceramic components. (5 Lakhs)	
5.5	Design of shear walls for multistoreyed buildings using precast components. (6 Lakhs)	
5.6	Development of methods of analysis and design of tall buildings with reinforced brick masonry shear walls. (12 Lakhs)	
5.7	Research and development on production and use of ready mixed concrete (Refer $S_{15}G_1A_4P_{17}$)	
5.8	Continuous extrusion process for prestressed concrete. (3 Lakhs)	
5.9	Analysis and design of in-filled frames. (5 Lakhs)	

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*Development Contracts to be recommended to

NRDC..........National Research Development Corporation.

IMDC/Instrument.........(Proposed Instrument & Machinery Development Corporation) for funding. On basis of the Sectoral group reports which have identified specific items, their need, present and projected demand, and possible places where expertise is available for development of the above equipments.

1	2	3
6	**Development of prefabrication systems :**	149.0
6.1	**Large-Panel Systems :** (27 Lakhs)	
	(i) Studies on solid, cored, ribbed and sandwiched panels. (5 Lakhs)	
	(ii) Studies on large panels as a three dimensional structure. (2 Lakhs)	
	(iii) Optimum design of wall panels with minimum weight or minimum steel consumption. (2 Lakhs)	
	(iv) Research on casting methods and development of indigenous know-how for setting up complete plants for the manufacture of large panels. (10 Lakhs)	
	(v) Studies on strength, durability and economy of large panels made of hollow clay blocks. (3 Lakhs)	
	(vi) Studies on panels made of cellular concrete and structural grade light weight concrete. (5 Lakhs)	
6.2	Development and study of joints and finite element methods of analysis of stresses and deformations in industrialized buildings. (1 Lakh)	
6.3	Development of thermally prestressed concrete products. (2 Lakhs)	
6.4	Systems approach to mass housing ; Planning of housing industrial estates (precast concrete products) throughout India; Preliminary feasibility studies. (Refer Group 6 also) (3 lakhs)	
6.5	Application of operational research methods for prefabrication and industrialization. (1 lakh)	
6.6	Computer generation of design charts for selection of prefabrication components of modular sizes. (2 lakhs)	
6.7	Dynamic and blast loading effects on prefabricated buildings including seismic effects. (2 lakhs)	
6.8	Development of network methods of planning for prefabricated projects. (1 lakh)	
6.9	Development of beam column assemblies with load-bearing panel walls. (1 lakh)	
6.10	Model studies and stress concentration problems around openings. (2 lakhs)	
6.11	Studies on integration of services in prefabricated buildings. (2 lakhs)	
6.12	Studies for arriving at tolerences in prefabricated structures. (1 lakh)	
6.13	Feasibility studies on the establishment of an industry for concreting accessories such as inserts, anchors, hooks, bar spacers, and splices. (1 lakh)	
6.14	Investigation on fibre-reinforced concrete for precast products sleepers. (2 lakhs) (Refer $S_{15}G_1A_4$ also)	
6.15	Field studies to determine indices such as cost of factory made components, total cost, site labour, total labour, manpower, useful area per unit volume, etc. (1 lakh)	
6.16	Studies on thermal insulation, acoustics, fire-rating and weather-proofing of prefabricated systems. (7 lakhs)	
6.17	Setting up R&D facilities in precasting factories. (8 lakhs)	
6.18	Undertaking large pace-setting experimental projects using prefabrication to develop technological know-how and to study short and long term behaviour. (Refer P_4, also S_{15} G_{13} P_3) (80 lakhs).	
6.19	Development of Box Systems—method of analysis and design tests on models and prototypes, and evaluation of economies. (5 lakhs)	
7	Development of construction equipment for partial and full prefabrication (Refer Group 2)	
Others		
8	**Prefabrication and Industrialized Building Systems as applied to Industrial and Storage structures. (Refer also Group 8)**	13.0
8.1	Control theory and dynamic programming methods for optimum design of concrete roof trusses. (1 lakh)	
8.2	Development of standard designs of structures using multiple cylindrical shells, folded plates etc. (Refer also P_3) (2 lakhs)	
8.3	Development of standardised optimised designs for precast hyperboloid shells. (1 lakh)	
8.4	Studies on composite openweb joints including space truss with concrete slabs. (1 lakh)	

1	2	3
8.5	Studies on castellated beams for optimal design. (1 lakh) (Refer Also $S_{15}G_1A_5$ for stress concentration and other basic studies)	
8.6	Research and development on ferro-cement roofs and roofing components. (Total 2 lakhs) (Refer Group 1, Subgroup 4)	
8.7	Studies on prefabricated silos, bins, etc. (Refer also Sector on Khadi and Village Industries). (Total 5 lakhs.)	
9	Development of Architectures suitable for prefabrication and industrialized building systems.	7.0
10	**R & D relating to mass-produced precast components such as sleepers, pipes, poles, etc.**	10.0
10.1	Studies on prestressed concrete railway sleepers by long-line, stress-bench and positive anchorage methods. (6.0 lakhs)	
10.2	Studies on ballast-less track (paved concrete railway track) (4.0 lakhs)	
10.3	Other projects regarding pipes, poles etc in G_3A_2. . . . R & D in Structural Engineering.	
	Total G_3A_1	650.

G_3 : Structural Design and Construction Techniques including Prefabrication

G_3A_2 : R & D in Structural Engineering For Buildings and other Structures

1	2	3
	PART I—BUILDINGS (Housing, Industrial and Institutional)	35.
$S_{15}G_3A_2P_1$	**Loads**	
1.1	Load surveys on buildings of different occupancies such as residences, offices, schools, warehouses, etc. (15 lakhs)	
1.2	Wind loads on buildings and other structures. (15 lakhs)	
1.3	Statistical approach to structural safety and evolution of loading standards. (5 lakhs)	
2	**Research and Development in Reinforced Concrete**	80.
2.1	Research on the analysis and design of slabs including development of design principles based on Yield Line and Strips Methods Assessment of design practices for roofs of mass construction. (See Group 6) (15 lakhs)	
2.2	Investigations on very High Yield and High Bond Deformed Bars: (30 lakhs) (a) Development of deformed bars of 60 to 80 Kg/mm yield strength. (5 lakhs) (b) Bond studies (5 lakhs) (c) Behaviour of structural components reinforced with the above bars. (20 lakhs)	
2.3	Research on behaviour of structures subjected to bending, shear, torsion and combined states. (10 lakhs)	
2.4	Behaviour of columns & frames under axial loads, bending and biaxial bending. (10 lakhs)	
2.5	Investigations on the behaviour of structural components made out of fly ash. (15 lakhs)	
3	**Research & Development in Prestressed Concrete**	55.
3.1	Methods of prestressing—Development of electro-thermal, chemical and other prestressing techniques. (10 lakhs) Refer also $S_{15}G_3A_1P_{6.3}$	
3.2	Development of design principles for partially prestressed concrete structures, especially for bridges and industrial buildings. (15 lakhs)	
3.3	Cracking and deflection of partially prestressed concrete structures. (10 lakhs)	
3.4	Behaviour of partially prestressed structures in shear. (5 lakhs)	
3.5	Behaviour of post-tensioned segmental prestressed concrete structural members using epoxy resins. (10 lakhs)	
3.6	Investigations on the behaviour of prestressed structural components made out of fly ash. Refer also $S_{15}G_3A_1P_{5.2}$ (5 lakhs)	

	2	3
4	Setting up of a Steel Structures Research Council for undertaking & coordinating R & D tasks in steel structures; bringing out handbook, organising courses & seminars. Refer also $S_{15}G_1A_5$. (Details in Appendix-3) (Also of interest to Group—Industrial Buildings).	100.0
5	**Research and Development in Masonry Structures.**	10.0
5.1	Study and behaviour of brick masonry components, including reinforced brick masonry slabs (5 lakhs).	
5.2	Development of design criteria for reinforced brick shear walls. (5 lakhs).	
6	Research and Development in composite structures using steel, reinforced and prestressed concrete. (Includes study of brick walls on R. C. beams).	10.0
7.	Evolving criteria for structural design of industrial buildings	10.0
8.	Evolving criteria for analysis and design of Tall Buildings.	10.0
9.	Research & Development in Public Health Engineering Structures such as Water Tanks, Settling Tanks, Sewage Disposal Works, etc.	5.0
10.	Research on economical structural schemes for long-span structures shells and suspended roofs.	20.0
11.	Criteria for the design and studies on the behaviour of structural components made of Ferrocement, Fibre Reinforced Concrete & Reinforced Polymer concrete. (Refer also S_{15} G_1A_4 regarding materials research)	15.0
12.	Research & Development on structural use of timber; development of design and fabrication techniques for Laminated Timber Structures. (to also include form work structure analysis, evaluation and design)	5.0
13.	Research & Development on structural behaviour for the building components made of Plastics. for e.g.; Bamboo reinforced foamed polystyrene roof units.	5.0
14	**Computer Software Development for Structural Engineering.**	40.0
14.1	Development of computational facilities and software for the analysis of space frames, shell roofs, folded plates, prestressed concrete structures, grids, cooling towers, chimneys, thin and thick pressure vessels, raft and shell foundations. (15 lakhs)	
14.2	Development of optimisation software for skeletal structures, beams, plates and shells. (5 lakhs).	
14.3	Development of library of programmes for finite-element analysis in linear and non-linear range. (5 lakhs).	
14.4	Development of finite-element methods for the post-cracking analysis of reinforced and prestressed concrete structures. (5 lakhs).	
14.5	Development of problem-oriented languages. (5 lakhs).	
14.6	Development of computer programmes for the design of structures including use of computer graphics. (5 lakhs).	
15	Setting up of Model-Analysis Centres (Refer panel on Natural Resources Sector on Water Resources).	
16	Development of unified modern codes of practices for the design of concrete structures:	25.0
16.1	Research & Development work both in basic and applied fields.	
16.2	Laboratory investigations (including purchases of equipment for same)	
16.3	Experimental construction.	
16.4	Seminars and publications.	
17	Preparation of Explanatory Hand-Book for I.S. codes relating to structural engineering. (Refer Group 14-Miscellaneous Projects)	
18	Development of Design Aids & Hand-Books Based on .I.S.Codes (Refer S_{15} G_{14} P_1).	
19	Development of Structural Principles and Guidelines for the rational design of Formwork & Temporary Structures. (For Construction Safety)	2.5
20	Studies on defects in structures. Structural Failures and their investigations.	2.5
21	**Extension Services In Structural Engineering.**	
21.1	Organising advanced refresher course/workshops for practising engineers.	5.0

1	2	
21.2	Establishing a clearing house for the publication of technical reports, reprints, and translation of papers from other languages.	5
	PART II—OTHER STRUCTURES	
	(Refer also to Panel 2—Sector on Water Resources, Panel 7—Transportation, Panel 17—Marine Resources).	
22	Research and development in transmission line towers and other towerlike structures including the setting up of a research-cum-testing station. Including T.V. Towers.	30
23	Spatial structures. Telescopic Antennae for Space Applications	10
24	Steel and light-metal structures including structural applications of aluminium alloys. (Refer also S_{15} G_1 A_5)	
25	Research & Development in nuclear structural engineering including analysis and design of reactor containment vessels.	20
26	Cooling towers and chimneys. Optimal design.	10
27	Prestressed Concrete Pipes for water supply, sewerage, tunnels etc.	10
28	**Research & Development in Bridges**	25
28.1	Medium and long span bridges.	
28.2	Bridges curved in plan.	
28.3	Influences surfaces for bridge decks.	
28.4	Design and development of bridge bearings.	
29	Storage structures for Grains and other materials (Refer Sector on Consumer I)	
30	Research and Development in mass produced precast components such as poles, sleepers, etc. (Refer S_{15} G_3 A_1 P_{10} also)	15
31	Research and Development in pneumatic structures (similar to Democrete, etc.)	5
32	Research and Development in marine structures including jettys, wharves and break waters. (Refer Sector on Marine Resources)	
33	Development of design criteria for different types of machine foundations. (Refer Group 4)	
34	Concrete Structures for dams and other irrigation structures (Refer Panel on Natural Resources Sector on Water Resources)	
	Total G_3 A_2 :	565
	G_4: Foundations & Foundation structures (Includes Soil Mechanics & Foundation Engineerin Earthquake Resistant Building Design. (*)	
1	R & D in partly saturated soils (a) to evolve simple and standard procedure of exploration and field testing. (b) to study settlement trends of the soil under storage and heavy structures, pile groups. (c) to collect the information and bring out specifications and design aids for the foundation designs. Engineering case studies	25
2	Studies of Regional deposits . . . . (a) to combat swelling in expansive soils. (b) extend the utility of under reamed piles. Study battei piles. (c) behaviour of lateritic soil. (d) foundation treatment in off-shore soils. (e) behaviour of alluvial silt and granular deposits.	35
3	Preparation of standard designs for foundation elements. Study in novel/alternate forms of foundation elements (for mass housing, industrial structures like transmission towers, and tall buildings combined footings, rafts for heavily loaded structures on problematic soil deposits). Earthquake resistant designs.	30

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*For Projects of Soil and Rock Mechanics applied to River Valley Projects, see sector on water resources Panel on Natural Resources.

	2	3
4.	Soil and slopes stabilization. Landslides correction techniques. Procedures for the development of hill areas and border roads, Impermeabilization of granular soils.	15.C0
5.	Improvement of and foundation problems in reclaimed soils for residential flats and mass housing schemes for urban development in earthquake prone areas. Case studies.	8.C0
6.	Construction technology (including foundation excavations); diaphram wall constructions, and subway & tube railway constructions, and measurements for earthquakes and severe winds. Case studies.	10.C0
7.	R & D in the instrumentation for soil testing and the field testing	20.00
8.	To compile a data bank having information about the soil deposits of the country and the existing knowledge. To disseminate the information (see item 2 & 3 also).	5.00
9.	Foundation interaction in multistoried buildings, vibration isolation in structures and foundations behaviour of foundation soil system when a large number of equipments and vibration machines are accommodated on a common raft foundation. Earthquake resistant design of tall buildings. Case studies	30.00
10.	To study bearing capacity behaviour of soil during an earthquake	5.00
11.	Rational design of break waters & wharves tunnel linings	8.00
12.	R&D in underpining of foundations	9.00
13.	Machine foundations	10.00
14.	Training courses for the building industry and academicians	5.00
15.	To study earthquake and wind effects on bridges, marine and tower structures . .	30.00
16.	Problems of earthquake engineering related to mass housing rural housing, prefabrication and industrial Buildings. Engineering case studies.	10.00
17.	Converting the School of Training and Research in Earthquake Engineering into a Central Institute for Earthquake Engineering Research, for application in Civil Engineering Design and Construction. This proposed institute would undertake some of the above mentioned projects in conjunction with other institutions in earthquake engineering	20.00
	TOTAL G_4: . .	275.0

G_5 : Building Services

G_5 A_1 : Lighting and Ventilation (Natural and Artificial)*

I : Ventilation—Natural and Artificial.

$_5A_1P_1$	Air Movement in high density areas with special reference to Urban Housing Complexes (Lab. Studies). Application to actual planned complexes (for example: DDA) for Laboratory Simulation and Study.	1.25
2.	Field Studies on existing buildings for ventilation efficiency and correlate field and laboratory studies in six principal cities like: Delhi, Jaipur, Bombay, Trivandrum, Madras, Bangalore, Calcutta. Development of required field instruments.	4.50
3.	Assessment of external wind motion throughout the day in principal towns and cities (24 number) to correlate with ventilation requirements in buildings.	3.50
4.	Information dissemination and diffusion through publicity on Functional Requirements and Efficiency of Buildings for heat, light, ventilation and sound. Extensive documentation and information.	2.50
5.	Ventilation requirements in areas with polluted atmospheres like: Calcutta, Bombay, Ahmedabad; Delhi (sand and coal dust).	3.00
6.	Training of teachers in Architectural and Civil Engineering Schools, of practising professional and building designers, of users, on Efficiency of Buildings for Climatic Conditions (Heat, Light, Ventilation, Sound) and Functional Requirements (in residential institutional and industrial buildings). Building Climatology and Comfort.	12.00
7.	Extension and Documentation of wind motion in buildings (with particular emphasis on natural and artificial ventilation) with illustrative examples (a) at professional level (b) user level. 1. Residential buildings. 2. Industrial and office buildings for different climatic zones of India.	1.00

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* Also of interest to G_8: Industrial Buildings; G_9: Institutional Buildings.

1	2	
	8. Development of design guidelines on mechanical aids for ventilation, with illustrative example for industrial, institutional and residential buildings, (for different climatic regions of the country).	2
	9. Development of methods for estimating air changes in buildings.	0
	10. Setting up laboratory facilities for study of Efficiency of Buildings from climatic viewpoints including ventilation studies in 2 academic institutions having wind tunnel facilities and Building Science laboratory.	12
	II : Lighting—Natural and Artificial.	
	11. Daylight availability in polluted industrial atmospheres for use in Building Design (Bombay, Calcutta, Jamshedpur and such areas as Kanpur, Cochin).	1
	12. Studies to decide task illumination levels for Indian subjects under Indian conditions, with special reference to Industrial/Office Buildings.	10
	13. Radiant heating of factories with different roofing and its influence on industrial workers so as to find methods of reducing the heat load in summer.	2
	14. Field studies on Artificial Lighting of Office and industrial buildings with respect to functional requirements and provisions of National Building Code. (This should be a co-operative project between the architects, research lab., ISI, and the users).	1
	15. Study of Permanent Supplementary Artificial Lighting of Interiors (PSALI) under Indian conditions of climate, and economics for industrial buildings, offices, and institutional buildings.	6
	16. Centre for Research and Testing on Lighting and Lighting devices, for buildings and urban and rural developments. (Establishment of extended testing facility to cope with increased production of lighting material, services, fittings and accessories). Joint Govt. Industry Centre.	4
	17. Publication of data relating to daylighting in office/industrial/residential buildings; for use by architects and building designers; and to users, design aids to designers on Lighting of Buildings.	5
	18. Strengthening of teaching programmes on "Lightening and Electrical Installations in Buildings" at degree (3 centers) and diploma level (2 centers).	1
	TOTAL G_5A_1	1
	G_5A_2 : Acoustics & Sound Insulation (including Partitions & Architectural False Ceilings)	
$S_{15}G_5A_2P_1$	Measurement of existing materials under standardised and inter-comparable conditions with all possible combinations in respect to : (a) Sound absorption of materials and components (b) Airborne sound transmission (c) Impact transmission A data bank (computerised or otherwise) is to be compiled listing other properties of materials. The studies would be carried out on the compilation to grade the materials to suggest new materials/combinations. The compilation and the results of the studies would serve the research workers, commercial interests and the building industry as a whole. Disparity in measuring techniques existing at different places in the country are to be pointed out and commented on. Improved measurement techniques are to be worked out. Apart from the material the factors which can improve sound insulation are to be studied. In the phenomena listed above, governing aspects are to be investigated and to be applied in developing new materials like improved lightweight products. To provide testing facility to the building industry in the above fields. Refer also $S_{15}G_1A_{13}$ regarding sound insulation materials.	22
	2. To study noise disturbances from the environmental fixtures in the building like windows, air-ducts, service pipes, kitchen accessories and other fittings. Categorising the noise into various grades. Studies for eliminating them and to improve the fixtures designs/materials. Nucleus at NPL is proposed to be developed as National Institute for Building Acoustics.	1
	3. Training, dissemination of information and framing of practical guidelines. Design Aids and Explanatory hand book. (Refer $S_{15}G_{14}P_1$ also)	2
	Total G_5 A_2	3

1	2	3
	G_5A_3:Thermal Environmental Services Including Air Conditioning & Heating, Cold Storage Buildings & Buildings For Tropical Climates	
$G_5A_3P_1$	Development of computer programmes and test facilities for the accurate determination of cooling loads making studies for optimization of designs. Use of solar energy systems for refrigeration purposes and for air-conditioning.	20.0
2.	RDD on design (materials, structural, thermal) of buildings for tropical climates for better thermal efficiency.	5.0
3.	R & D in design of cold storage structures.	5.0
4.	Development of a National Research Institute for refrigeration and airconditioning where most of the testing, design and development of all equipment related to air conditioning and refrigeration may be taken. Development of package air-conditioners climatology laboratory for buildings. Also proposed by CSIR in their 5th five year plan as Research Associate on 50:50 basis. Rs. 42 lakhs would be financed by CSIR and the private industry (Refer P_1,P_2,P_3 above)	42.0
	TOTAL G_5A_3	72.0
	G_5A_4 : Fire Protection of Buildings	
$G_5A_4P_1$	R & D in fire equipments, appliances, accessories and ingradients, such as hydrants, emergency lighting, sprinklers, inert gases.	10.0
2.	R & D in water shortage, distribution, wastage and damage at the time of fire.	2.0
3.	To study methods and materials for the prevention of fire-spreading. Fire loads in building Fire causes of damages. Burning behaviour of materials. Public education about fire awareness.	20.0
4.	To establish a national testing facility for fire equipments, appliances and building materials (with regards to their burning behaviour). Fire Ratings of buildings. Determination of fire loads of office buildings.	12.0
5.	Fire fighting awareness, communication, evacuation at the time of fire. Fire Engine movement.	1.0
6.	R & D in fire resistant-coatings in urban and rural houses. Development of various types of the retardants.	4.0
7.	R & D on fires in lifts.	1.0
8.	Fire fighting in rural/slum areas. Solution for areas like M.P., Rajasthan. Fire statistics collection on a country-wide and state-wide level (R and D towards development of methodology)	5.0
	TOTAL G_5A_4	55.0
	G_5A_5 : Plumbing (Water Supply & Sanitation) other solid wastes refuse disposal services.	
$G_5A_5P_1$	To Design, install and study the behaviour of P.V.C. and high density polythene pipes for water distribution and waste collection systems for certain types of building complexes (Refer $S_{15}G_1A_9$)	4.50
2.	Working of low cost water treatment units, such as double layer filters, horizontal filters, pipe grid filters, stage filters, compact settling units, hydro-cyclone, gravel flocculators etc.(Refer also S_{15}.G_5)	4.50
3.	Working of low cost waste treatment units such as oxygen ponds, oxidation ditches, oxidation channels, aerated lagoons, anaerobic filters, aquaprivies, percolating tanks etc. (Refer also S_{15}.G_5)	4.50
4.	To develop suitable collection, drainage and disposal systems for cattle sheds etc., attached to rural buildings.	1.30
5.	To set up a planning group consisting of public health engineer, architect, civil engineer, electrical and electronics engineer and other concerned personnel. This group after studying the problems of high density building complexes will develop an integrated approach for different services to be rendered and will suggest suitable R &D problems to be taken up.	2.25

1	2
	6. To develop self contained waste collection and disposal units for high density building complexes so as to utilize the waste water.
	7. To develop suitable and economical procedure for design of water supply systems including water storage and distribution for high density building complexes by applying modern techniques of analysis.
	8. To study and evaluate the working and economics of the hydro-pneumatic system of internal water distribution of multi-storeyed buildings.
	9. Design of water distribution systems for tall buildings, considering effect of fire fighting demands.
	10. Establishment of "leading unit" for sanitary appliances keeping in view Indian usage and habits so as to arrive at rational design criteria for sizing of drain pipes especially in tall buildings.
	11. To study the problems of dry refuse collection disposal system for high density building complexes.
	12. To survey environmental conditions at certain important railways platforms and bus stations and to suggest suitable layouts and design for water supply and sanitary services for such places.
	13. To develop suitable compact units of disinfection of water, removal of iron, fluorides and salinity. For eg. Pot Chlorinators.
	14. To develop non-corrosive and more sturdy hand pumps—for both private and public buildings equipment and accessories.
	15. To analyse the contribution to air pollution by the building complexes as well as the effect of air pollution on the building complexes and suggest remedial measures.
	16. Rural Water Supply, Drainage and Sanitation RDD Centres (5 centers) (Refer Group 7 also) Also Projects 3,4, & 13.
	17. Central Level Coordination Projects on Public Health Committee for technical secretariat
	TOTAL G_5 A_5
	G_5 A_6 : Electrical Installations and Lightning protection
$S_{15}G_5A_6P_1$	R & D in the improvement of conductors, cables; development of new conductive materials; R&D in electrical accessories like switches, protective devices, wiring supplementaries, indicator lamps, push buttons, roller guide shoes (Refer P_5 for funding)
	2. R & D in sub-station equipment and accessories including earthing.
	3. R & D in lightning protections for all types of buildings.
	4. Designing of installations, optimizing wiring for a given requirement, R& D in installations, accident prevention and safety procedures.
	5. Institute for Electrical Research and Development Organization including testing facilities for electrical installation and lightning protection. Also included in the CSIR 5th plan as a R A conjecture on 50:50 basis. Rs. 42 lakhs are to be spent by CSIR.
	TOTAL G_5A_6
	G_5A_7 : Vertical transportation; lifts and escalators, stairways; transportation of men, material & equipment within buildings
$S_{15}G_5A_7P_1$	To establish testing facilities of mechanical components of lifts such as buffers, safeties, wire ropes, worms and gears, sheaves, springs. Establishment of facilities for study of structural and architectural system and suitability of lift, escalators installations in high rise buildings.
	2. Study of behaviour of lifts at the time of fire and recommendations for safety rules. (Refer also $S_{15}G_5A_4P_7$)
	3. Study of stairways, transportation of men, materials, equipment for all types of buildings.
	4. Setting up training facilities for technical staff for maintenance and repairs; development of methodology for maintenance.
	TOTAL G_5A_7

	2	3

G_5A_8: Waterproofing, Damp Protection And Pest Control

A_8P1	To devise effective methods of damp protection by standardizing specifications and materials including treatments to bricks and mortar etc. To improve design against leakage and dampness in underground structures. To improve and standardise waterproofing on terraces and walls.	5.0
2.	To study and check salt-petre efflorescence a rising in brick masonry. Extension work	2.0
3.	R & D fillers in expansion joints and sealing of joints of prefabricated components in buildings.	5.0
4.	To develop effective treatments and remedies against termites (white ants) and pests in building components.	4.0
	TOTAL G_5A_8 .	16.0

G_5A_9: Integration Of Building Services

$_9P_1$	R & D towards Integrated Design of Services in various types of buildings (dwellings, industrial and offices) including storage spaces	10.0
	TOTAL G_5A_9 .	10.0
	TOTAL $G_5(G_5A_1$ to $A_9)$	Rs. 450.0 lakhs

G_6: Urban Housing And Physical Planning

$_5G_6P_1$	Determination of functional dimensions and anthropometic data relevant to building design through full-scale trials (in a Building Planning Laboratory).	7.0
2.	Development of type-designs of dwellings and housing layouts for various climatic regions and for different socio-economic classes, and materials availability.	10.0
3.	Standardisation and modular coordination	25.0
4.	Development of performance—oriented standards for dwelling designs for different regions to stimulate innovations in building technology.	5.0
5.	Development of evaluation models for urban housing schemes	1 5
6.	Studies of inter-relationships between house-types, densities and dwelling- behaviour in different regions of country.	5
7.	Studies of functions of public spaces (open spaces and public buildings) in various regions the country.	10.
8.	Planning studies for high-rise buildings for dwelling purposes	5.0
9.	Development of hand-book for dwelling designs for urban housing. spatial plans, climatological features as well as structural and other constructional details for various regions etc.	5.0
10.	Development of equipment and furniture for dwellings for efficient use of built spaces and improving functional efficiency.	10.0
11.	Prefabrication for urban housing, physical planning and structural design, environmental.	—
12.	Feed-back studies, user surveys of mass urban housing projects	10.0
13.	Maintenance problems in group housing schemes	1.5
14.	Assessment of technology in practice *vis-a-vis* current Indian standards for structural design of roofs, lintels and other parts of urban housing structures. Development of norms for rational use of steel and cement supply for house owners.	20.0
15.	All India Competitions for Low-Cost Housing, housing for user, promoting innovations in planning and technological designs (Development of performance requirement and methodology for systematic evaluation of alternate designs).	5.0
16.	Studies of Sequential Construction of mass housing projects. Economics of urban housing.	5.0
17.	Development work relating to the popularisation of Housing Cooperatives . . .	5.0

1	2	
	Physical Planning (See also Sector on Urbanisation and Sector on Environmental Quality)	
18.	Development of guidelines for drawing up of project-oriented Master Plans for medium size and small urban areas.	3
19.	Performance Oriented Standards for Physical Planning	5
20.	Studies on Municipal Bye-laws, regarding building regulations from climatic, functional and environmental viewpoints. Rationalisation of building regulation and control based on surveys and laboratory/field simulation.	5
21.	Studies of the Relative Economics of Transportation and Housing including inter-relationships between traffic noise and housing.	4
22.	Studies of the Role of Physical Planning in Promoting Social Integration, in various parts of the country.	5
23.	Studies of planning problems of urban centres/urban developmental areas. Density standards etc.	5
24.	Studies of Local Administration with respect to Urban Services, in towns of different sizes in different parts of the country.	5
25.	Urban Housing and Climatology Study of ecological-climatological changes in zones of influence of major cities due to urban development.	15
26.	Study of human settlements, their size and locations	10
27.	Agency for Large-scale Experimental Construction for Urban Housing, with regional centres.	60
	TOTAL G_6 .	247.
	G_7: Rural Housing And Development*	
$S_{15}G_7P_1$	Surveys-region wise survey of existing practices of rural construction and locally available raw materials-Research areas-evolving/suggesting improvements in these items.	5.
2.	Testing-Organising testing facilities. Research areas—Development of simple field tests for assessing qualities of various materials and constructions. Performance Standards and Test evaluation.	5.
3.	Type designs-research areas—Evolving type designs of houses and other rural buildings	5.
4.	Environmental Improvement-R & D areas—Evolving suitable & simple methods of disposal of various wastes, provision of safe drinking water supply & improvement in environments. Sponsoring of R & D work. (Also refer to $S_{15}G_5A_5P_{16}$).	15.
5.	Spatial planning—R&D areas—Laying down norms for spaces for various buildings, areas of plots, layout of villages, etc. in conformity with local requirements. (Refer Sector 15.1 also).	5.
6.	Building Methods—research areas—organisational aspects and promoting self-help construction programmes and related training. Development of suitable alternatives.	5.
7.	Extension work—Establishing Rural Housing Wings in 12 regions—for promoting rural housing activities. Includes rural roads, rural water supply and sanitation, physical planning for villages. Market town development.	180.
8.	Establishing Rural Housing Division in NBO—for co-ordination work of rural housing wings, R&D feedback & extension. Development work for effective extension in 12 regional centres (Rural Housing Wings).	5.
9.	(a) Construction of demonstration houses (in 12 regions) costing about 500 lakhs	60.
	(b) Development of model villages including environmental improvement (12 regions) costing about 300 lakhs.	40.
	NOTE :—A Revolving Fund for Rural Building and Model Villages. A good portion of capital cost may be recoverable. Additional funds may be taken as loans from recurring budget of ministries dealing with rural development.	
10.	Other rural demonstration buildings such as cattle sheds, poultry houses, animal houses, grain silos, school buildings, health centres etc.—for promotion of new/improved materials and techniques. (Budget of 100 lakhs in provision of 15 crores in Sector on Khadi and Village Industries).	
	Note :—Development of Villages Cottage Industry as part of a village house. Small Scale Industry buildings also envisaged.	

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*Refer $S_{15}G_1A_{14}$ relating to Rural Materials; $S_{15}G_5A_5P_{16}$ relating to rural sanitation; and 15.1 G_4 for Rural Development vis-a-vis Urbanisation.

1	2	3
	11. Information and Documentation (G_{12})	
	(i) Production of films, slides, film strips etc. for promoting various rural housing aspects.	—
	(ii) Profusely illustrated publications e.g. hand books, manuals, simple bye-laws, designs of houses, pamphlets, posters, charts, for promoting various rural housing aspects.	—
	(iii) Seminars, training & orientation courses.	
	(a) Seminars	2.0
	(b) Training and orientation courses for technical staff engaged on rural housing works.	3.0
	12. Sponsoring of R and D Centre for Rural Building in CBRI by NBO . . .	50.0
	TOTAL G_7 .	380.0**

The following R&D Projects Indentified by NCST Panel 15: Housing, Urbanization and Construction Technology; Sector on Housing & Construction Technology (Hct); Planning Group 7 on Rural Housing & Development, to be Budgetted in NCST Panel 24 : Khadi & Village Industry

1. Integrated Technology for Rural Development Systems Analysis at University of Roorkee (43.36 lakhs).
2. Development of a **Rural Small Scale** Cement Industry based on controlled burning of **Rice Husk** and mixing with powdered lime and powdering the mixture. Field Trials in the rural areas of Eastern Region. (19 lakhs).
3. R&D Project on "rural materials" (219 lakhs). . . . .
4. R&D Project Relating to Rural Roads, Water Supply, Sanitation and Village Planning ($S_{15}G_7P_{10}$) (100 lakhs).

G_8 : Industrial Buildings*

$S_{15}G_8P$	Research Design, Development, (including Design Aids) on Industrial Buildings, R & D relating to Prefabrication and Industrialised Building Systems R & D in Structural Engineering as relating to Industrial Organisations. Buildings R&D in Foundations Structure including Earthquake Resistant Design already budgetted in the respective panels. The following topics cover the scope of R & D Work on Industrial Buildings :—	200.0

1. Classification of industries for providing buildings
2. Location planning including area plot plan
3. Planning standards and Typification for Industrial Buildings ($S_{15}G_3A_1P_2$ in appendix).
4. Ergonomics related to plant lay-out of industries
5. Optimization of Industrial Structures for each type (Refer to Group 3.2-R & D in Structural Engineering)
6. Environmental efficiency of Industrial Buildings (Refer to Group 5.1-Building Service-Lighting and Ventilation)
7. Construction planning & management of Industrial Buildings (Refer Group 10)
8. Pollution control, waste treatment and disposal including reuse of water for industrial purposes (Refer Group 5.5)
9. Services & Utilities
10. Safety Standards for Industrial Buildings
11. Maintenance management in Industrial Buildings
12. National Code of Practice for Industrial Buildings. Handbook on Industrial Buildings ($S_{15}G_{14}P_1$)

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*Refer $S_{15}G_1A_{14}$—Rural Materials; $S_{15}G_5A_5P_{16}$ relating to Rural Sanitation; and $S_{15.1}G_4$ for Rural Development *vis-a-vis* Urbanisation.

** This list does not include other Rural Technology Projects (Such as Rural Development Technologies, Cement from Rice Husk; R&D, Extension Services by NBO, agricultural academic institutions on improvement of quality of Life in Rural Areas; Sponsoring Projects).

1	2	3
	13. Training and Extension programmes	
	14. **Council for Industrial Buildings.**	
	(a) R & D Centre for industrial structures	
	(b) R & D for environmental efficiency	
	(c) Journal of Industrial Buildings. This Council will maintain liaison between research, industry and educational institutions.	
	Total G_8	200
	G9 : Institutional (including Functional) Buildings*	
$S_{15}G_9P_1$	Research, Design, Development on following types of Institutional Buildings :—	180
	1. Education Institutions-Schools (primary, middle, high), Colleges, Universities.	
	2. Hospitals and Health Care Institutions.	
	3. Office Buildings (including Tall Buildings)	
	4. Tourist Centres-Hotels, Guest Houses.	
	5. Shopping Centres.	
	6. Buildings for Community Facilities (including Public Conveniences)	
	7. Sports and Recreational Buildings.	
	8. Civic Centres.	
	9. Buildings for Civil Defence-Air Raid Shelters.	
$S_{15}G_9P_2$	Development and Extension Work. Preparation of Design Handbooks, Explanatory handbooks of codes of practice relating to Institutional Buildings (by NBO and ISI). This work would be coordinated centrally but would be sponsored by various Public and Private Sector Organisations. Advisory Boards and Development Groups would be set up in NBO for the purpose of coordination.	120.
	Total G_9	300.
	G_{10} : Building Practices, Productivity and Management	
$S_{15}G_{10}P$ 1.	Rationalisation of specification and standardization of schedule.	10.
2.	Manufacture of building materials-identification of items for study and research (Productivity aspect).	5.
3.	Study regarding additional units and expansion of existing units for manufacture of materials. (Refer $S_{15}G_1A_0P_2$)	[illegible]
4.	Building construction practices. Studies on traditional construction practices for dwellings and other constructions in various parts of the country. See also P_{10}	10.
5.	Agency for execution (Role of government sponsored construction agencies).	0.
6.	Departmental execution (Evolution of systems and procedures).	0.
7.	System of contracts (contract document).	1.
8.	Standard Design for repetitive work.	5.
9.	Systems of Quality Control (setting up of testing facilities).	1.
10.	Case study of construction works. Documentation of case studies. Delays in construction Industry-Cases; Details Study.	20.
11.	Method Study of work in the field. (Work study of productivity in construction operations).	10.
12.	Incentives for construction work at site, from Productivity and Quality control.	5.
13.	Labour welfare in construction "industry".	1.
14.	Prevention of accidents in construction works.	5.
15.	Management training for construction staff. (Development of educational material centrally making use of expertise available all over the country).	20.

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*Refer also to Group 3, A_1 and A_2, Group 4

*Refer also to Group relating to Physical Planning and Sector 15.1 (Urbanisation) relating to densities and standards.

1	2	3
16.	Institution of construction management cell at centre and construction agencies	
	(i) Centre	10.0
	(ii) Other agencies (5 selected agencies) for e. g. : HUDCO, NBCC	40.0
17.	Programming techniques for construction planning and execution	5.0
	(i) Training & extension work. (P_{15}, P_{16} above)	
	(ii) R & D work.	
18.	Scientific feedback on actual practices.	3.0
19.	Training of Artisans (Develop)	1.0
20.	Study on Registration of Contractors including Engineering Contractors (P_{16})	
21.	Maintenance of buildings : Maintenance Engineering	
	(i) System and Procedure.	1.0
	(ii) R & D work (Offices, hotels, industrial and other institutional buildings).	2.0
	Total G_{10}	156.0
	G_{11} : Education Training and Manpower	
$S_{15}G_{11}P_1$	In-Service training for building personnel in Central P.W.D.& Public Sector Organisations (Bureau of Public Enterprises) for all over the country.	55.0
2.	Manpower Studies in Building Industry.	7.5
3.	Study Economics of Building Industry.	7.5
4.	Construction Statistics Cell/Centre in Central Statistical Organisation; Central Construction Statistics Centre.*	30.0
5.	Housing Statistics. (See item 4 above)	20.0
	Total G_{11} .	120.0
	G_{12} : Information and Documentation	
$_{15}G_{12}P_1$	Survey of the available information services, existing facilities and the user needs related to the field of Housing and Construction Technology, (This includes the cost of man-power, materials, production of reports on the findings, postage etc. and is proposed to be spent immediately, perhaps in 1973-74. This basic information will be needed for working out a detailed total infrastructure of the I&D system)	0.5
2.	Allotment of funds for the central I&D organization, for the entire plan period ;	
	(a) Acquisition of literature	12.5
	(b) Equipment (including reprographic units, mechanised units such as punch card equipment etc).	13.0
	(c) Journal on Housing and Building Technology	3.0
	(d) Translation service (from European languages into English and from English into Regional languages)	5.0
	(e) Abstracting service	5.0
	(f) Publicity (including displays, exhibitions, audio visual demonstrations etc.) . .	3.0
	(g) Seminars, Symposia, Workshop etc.	2.0
	(h) Personnel	10.0
	(i) Contingency	2.0
3.	Establishment of new regional I&D Cells and strengthening of existing I&D Centres in specialized areas such as CBRI, CRI, SERC etc.—about six units—all over the country —for the entire plan period. Building Data Centres—Technical, Economic, Performance of Materials, Components and Structures. Data from materials testing laboratories. Refer Group 13 also.	44.0
	Total G_{12}	100.0**

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*Involves Ministry of Works and Housing, Railways, Defence, Industrial Development, Steel, Heavy Industry and other Ministries at Centre, States, Municipalities.

**Note: (This may be dovetailed in the Construction Industry Component of National Information System for Science and Technology, proposed by Dept. of Science & Technology) Documentation Component for Housing & Building Technology as covered by above items 1,2,3 and as such Data Processing and retrival as part of NISST above : Above sum of Rs. 1.00 crore is needed for Special Documentation needed for this Sector

1	2	3
	G_{13}: Extension Services in the Building Industry	
$S_{15}G_{13}P_1$.	Sponsoring research in practical problems by National Building Organisation to universities, state engineering laboratories and other research agencies.	30
2.	Development works for adoption of new techniques by NBO, HUDCO, HHF in conjunction with other organisations.	25
3.	Large scale extension/experimental construction for development of mass low cost housing incorporating new technology and promotion of large scale housing by precast housing factories.*	225
4.	N.B.O. Liaison Cells and Building Centres in major towns in conjunction with universities, IIT's, professional bodies. Also refer to S_{15} G_{12}. At least 10 centers.	50
5.	In-service Training Schemes. (Refer $S_{15}G_{11}P_1$).	
6.	Demonstration-cum-training centres for production of new/substitute building materials (Budgetted in Group 1 S_{15} G_1 P_2)	
7.	Setting up Rural Housing Wings in states including establishment expenditure of Rural Housing Division in N.B.O. ($S_{15}G_7P_7$, P_8, P_9).	
8.	R&D Liaison Cells/Regional Centres of CBRI in Western, Southern, Eastern, Central Zones in conjunction with universities, IIT's (so as to utilise existing facilities as a start). 5 Cells of CBRI to take care of building research and development problems for different regional (materials availability, practices and social conditions) and climatic conditions.	60
9.	R & D Liaison Cell in CPWD.	8.
10.	R & D Liaison Cell and Development Cell for Industrial Building and Townships in Bureau of Public Enterprises, for extension work in Public Sector Undertakings.	12.
11.	R & D Liaison Cell in HUDCO. Housing Development Cell in HUDCO for servicing State Housing Boards. Sponsoring of RDD Cells in State Housing Boards by HUDCO (as part of plan, non-plan expenditure of HUDCO).	
	Total G_{13}	410.
	G_{14}: Miscellaneous—Development and Extension Programmes**	
$S_{15}G_{14}P_1$.	**Development Programmes regarding implementation of codes and standards into actual practice for Civil Engineering Construction Technology.**	
	(a) Development of design handbooks, explanatory handbook and design aids on National Building Code of 1970. (A total of about 10 such books are contemplated). Very important Major Thrust Area. ISI would coordinate this scheme and contract out positions of the series of documents with experts/specialists from universities, research laboratories, practising professionals. Non-availability of the design aids, explanatory handbook has been identified in many planning groups of Sector 15 as a major inhibiting factor in speedier implementation of the Code, which could give substantial economies. Project of immediate importance.	30.
	(b) Development of Design Aids and Explanatory Handbooks on: (1) Reinforced concrete structures. (2) Steel structures-use of plastic design. (3) Other aspects of building and civil engg. structures (Poles, pipes, water tanks, grain storage structures etc. A total of about 15 handbooks in addition to those given above are suggested).	30.
	(c) Extension Activities in terms of Promotion of National Building Code and other codes relating to construction industry.(Holding of workshop sessions for municipalities, states and central agencies, public sector organisation, practising professionals throughout the country). Preparation of Centralised Extension Information with help of experts throughout the country. Implementation of Extension Programmes regarding application of codes of practice throughout the country, for	55.

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*(Also refer to S_{15} G_3 A_1 P_6 : 18 projects of 80 lakhs, Refer to Appendix for details of large scale experiment construction using Prefabrication techniques by HHF).

**Also Refer to G : General Projects for Rs. 150 lakhs.

1	2	3
	both rural and urban sectors—Total of about 20 centres to run programmes at various levels—supervisor, junior engineers upto Chief engineers at different levels of depth, breadth, in various phases of construction activities. Project of Immediate Importance.	
	Major thrust Area.	
	Extension.	
	Need to have an Extension Cell in IST.	
	(1) Special Programmes/Workshop Sessions for speedier updating of Municipal bye-laws, State PWD Specifications according to National Building Code and ISI Codes of Practice.	
	(2) Programmes for Implementation of Codes into Practice, development of more design aids, explanatory handbooks other than items a and b.	
	Total for a, b, c	115.00
2.	Setting up of an International Consultancy Bureau in Civil Engineering including Structural, Highway and Public Health Engineering and including computer software. (See Appendix 3 for details)	78.00
3.	"Operation Save Steel in Industrial and Dwelling Construction"—Development of suitable strategies and methodology for the same. Methodology for developmnt of small/medium scale precast concrete products industries (Refer Group 3.1, 3.2 and 6).	4.00
	Total G_{14}	197.00
	Total for G_0 and G_{14}	347.00
	Grand Total for Sector on Housing and Construction Technology $S_{15}G_0$ to G_{14} :	Rs. 67.00 Crores.

Sector on Urbanisation

(Rural, Urban and Regional Development)

G_0: General Projects

$15{\cdot}1G_0P_1$	(a) National Council for Research in Integrated Rural, Urban and Regional Development (or National Reserach Board for Human Settlements and Physical Environment).	25.00
	(b) Sponsoring of RDD Projects requiring 1.00 crore for V Five Year Plan (See also group 1 to 5 of 15.1 for a tentative list of projects).	100.00
2	Setting up of a National Institute for Rural, Urban and Regional Development Systems.	95.00
3	Setting up of 4 Centres for Research and Training in Urban Development Management (Multidisciplinary Planning—Engineering—Management—Socio-Economic—Geography/Regional Sciences) (Specialised Training and Research Centres in Urban Engineering and Management).	80.00
4	Standing Group on New Towns to sponsor, coordinate and oversee R & D studies. Development of criteria and guidelines for rational, planning and integrated development of New Towns/"New" Industrial Townships, feedback on planning standards from Existing New Towns. (Refer group 3 of Sector 15.1).	20.00
5	Application of Science & Technology to Urban Development. System analysis Models for Indian Cities, through multidisciplinary groups. Adopted to critical or problematic towns and cities with many problems e.g. Slum Improvement Models. (Refer groups, 1, 4 of 15.1)	15.00
6.	Information Base for Integrated Development of Rural, Urban and Regional Systems, as part of NISST, for Rs. 100 lakhs. (Refer Appendix—$S_{15}G_{12}P$)	—
	Total $S_{15\cdot1}G_0$	335.00

1	2	3
	G_1: Planning Standards and Planning Methodology for Indian Conditions	
$S_{15.1}G_1P_1$	Development of different types of Urban Planning Models. Application to actual case studies of cities.	
	(a) Land Use Planning Model. Input-land availability in each zone of the city, the costs of transport between zones, and location of basic employment/ industry output—location of service jobs and distribution of residential population (At 4 Centres).	18
	(b) Econometric type, developed from time-series data and predicts the growth of population and immigration into metropolitan region year by year based on the knowledge of certain variables, some of which it may be possible to control as a matter of policy. (At 2 Centres).	4.
	(c) Model which takes as given, the alignment of a transit route and determines the optimum distribution of uses along this transit alignment so as to minimise travel costs. All 3 models concern specifically with the detailed planning of a metropolitan area. (At 4 Centres).	6.
	(d) Development of Regional Planning Model, which can test the effects of various location decision, and the effect of developing infrastructure at various points in the region on the eventual distribution of population and employment throughout that region. To examine the costs and ultimate population distribution resulting from various location decisions. Model should help to examine alternative urban growth strategies and their impact on costs and ultimate distribution of population, jobs and investment; employment potential and growth of backward areas. (At 4 Centres).	23.
2	(a) Research in areas relating to urban development requiring a Systems Approach and an effective inter-disciplinary effort. Example of Bombay—CIDCO; Ahmedabad.	15
	(b) Training Programmes which can equip a promising individual from any specific parent discipline for effective work, at least in a supervisory capacity, in other disciplines which are of importance in urban planning.	
3	Choice of mass transportation systems for urban areas, between a train system, a bus system, with buses operating on reserved tracks, and buses operating in mixed traffic. Another possibility is that of providing specially reserved cycle tracks. Each of the motorised transport systems becomes the most economical at different level of travel demand. Choice between these mass transportation systems in urban areas of different sizes with different growth potential: Detailed studies. Relationship between Transportation and Housing. (Refer also to $S_{15.1}$ G_2 P_{21}).	
3.1	R & D Studies for different urban areas with detailed data collection and analysis. (5 Centres).	25.
3.2	Studies for individual cities . . . . Chandigarh. . . . . Kanpur. . . . . Bangalore.	10.
4	R & D relating to desirable densities for urban development. (Much of our urban planning work so far has been based on density norms derived from western examples. On the other hand Hong Kong has much higher densities without observable ill-effects.) Studies to establish. a. Costs of infrastructure development vs. density b. Transportation costs vs. density c. Socio-psychological effects for different density levels; for distributing a given population within a given area (for example, high density compact zones of development with generous open spaces in between). d. trade-off point between lowered cost and environmental consideration (Studies at 4 Centres)	20.
5	Industrial Location Analysis with particular reference to agglomeration economics (based on three selected centres of major importance).	30.
6	Industrial Complex Analysis and its spatial implications including townships, housing, transportation (Case studies covering petrochemical, steel and heavy engg. complexes in different regions of the country)	40.
7	Systems Analysis of Settlements with specific studies of one or two resource regions. . . .	10.

1	2	3
8	Development of Analytical Models for Systematic Planning for Urbanisation, for Optimal Resources Utilisation and Increased Cost-Effectiveness. Socio-economic-engineering data base of regions to be fed into the models. (Application to Kanpur/Lucknow/Bombay-Poona regions).	15.00
9	"Developmental" contracts for carrying out Research and Design Development Projects for specific "Problematic" urban areas (See item $S_{15 \cdot 1} G_0 P_1$) such as Kanpur-Lucknow regions, Ludhiana-Amritsar, Ahmedabad-Surat-Baroda; Tenali Guntur-Vijaywada. 9 such areas have been identified; each project ranging from 5 to 20 lakhs.	75.00
10	Development of Urban Planning Methodology for Indian Conditions and application to specific urban areas (Town planning is at present based on standards and methodology as used in the west. Research study is needed to evolve indigenous planning methodology) (See P_1 and P_9 in this group.)	
11	Methodology of Evaluation of Alternative Low-Cost Housing Schemes in Urban Development. (Also refer S_{15} G_6).	6.50
12	To Study Urban Ecology aspects (computer and laboratory studies to combat pollution, considering Indian conditions). Development of Planning Standards and Methodology for above (Refer Group 5 in this sector also).	25.00
13	Development of an Environmental Design Model to enhance liveability of urban areas	1.00
14	Perception of Environmental Quality of built environment.	5.00
15	Site Planning and Environmental Design Standards in Physical Planning including trees and horticultural standards.	12.00
16	Spatial Standards for Urban and Rural Planning and Development.	12.50
17	To study the physical basis of residential standards on the basis of Prof. Oberlander's and others work on buildings.	10.00
18	Determination of optimum densities based upon Analysis of Density Standards against Social, Economic and Environmental Parameters. (See also P_4 in this group).	1.80
19	Research in dwelling equipment, furniture and floor space standards and inter-relationships between various types of dwelling units with dwelling behaviour.	5.70
20	Optimisation of the economic efficiency in the design of mass-housing units in the urban areas of hot-humid zones in India.	2.00
21	Organisation, Management and Location criteria of open spaces in an Arid-Zone Residential Colony.	1.50
22	Controlling the Advancement of Desert and Soil Stabilization Measures in Rajasthan Area.	2.00
23	Evolving Design Standards, Criterias and Requirements for Mass Transit Stations, Tunnels. (Refer Group 2, Project P_{24}).	10.00
24	Analysis of community facility standards in relation to specific social, economic and physical situations.	5.00
25	Evaluation of different housing development programmes in terms of community planning, undertaken in selected cities with reference to their specific social, economic and technological framework as related to different communities.	8.00
	Total $S_{15 \cdot 1}G_1$.	400.00

G_2: Strategy, Planning and Implementation Mechanisms for Physical Plans to get Balanced Regional Development (including Urban Transportation)

$_1G_2P_1$	Land Use Surveys for urban areas with population of 100,000 and above (including adjacent rural and regional surveys) for the country in conjunction with surveys made in agriculture. (Soil and Land Use Surveys);	100.00
2	Growth Pole as a tool of regional development, A case study of five selected urbanisation centres. (for e.g. Meerut).	30.00
3	Strategies for Urbanisation and Urban Priorities at National and Regional Levels . .	5.00

1	2	3
	4 Planning Approaches to Integrated Area Development	3.0
	5 Plan Implementation for Urban and Rural Settlements. Development of techniques .	2.0
	6 Urban and Regional Information System (Data Pool) (Part of National Information System for Science and Technology)	—
	7 Research and Development work relating to extension services for projects relating to	
	(a) Metropolitan Development Plans including National Capital Region (for e.g. Study of Meerut, Faridabad etc.)	50.0
	(b) Inter-state Regional Development Plans (Development of methodology, data base etc.) (Also See $G_1P_1.d$)	30.0
	8 Evolving parameters for centralization and decentralization for developing a strategy of balanced rural, urban and regional development.	10.0
	9 General Systems Studies of Urbanisation in India (An urban development strategy with specific case studies)	6.00
	10 Role of Urbanisation towards achieving balanced regional development in India, in general, and West Bengal, in particular, for example.	5.
	11 Systems Analysis, Dispersal and Rational Development of Towns, Market Towns, Villages and Inter-Communicating Systems for the Eastern Regional Area Development *vis-a-vis* Metropolitan Expansion of Calcutta.	20.
	12 Studies Relating to Urban Development of Kanpur-Unnao-Lucknow Region. Same consideration would be— (a) Land Use Resources (b) Housing (c) Transportation (d) Air Pollution & Sanitation (e) Water Supply (f) Systems Analysis (See G_1P_9 also)	25.
	13 Optimal Planning and Innovative Technology for Mass Housing and Community Centers for urban areas—Development, Evaluation and Field Studies.	5.
	14 (a) A Feasible Housing Policy in relation to the effective demand for Housing based on Housing Market Analysis—Policies, Programmes & Finance, (including analysis of urban land values)	5.
	(b) Development of an Integrated Housing and Land Development Policy (Policies, Programmes, Finance)	10.
	15 Effect of Site Layout on the Micro-climate Variation in a Housing Colony in an Arid Zone Region as well as in other parts of the country. Effect of built environment on micro-climate of cities (3 Studies)	10.
	16 Relocation of persons displaced by major urban development projects—comprehensive programmes of development relating to CMPO plan, CIDCO plans.	1.
	17 Size of city, level of services and municipal revenues to the 'carrying capacity' of a city (will cover selected towns/cities of each size class)	15.
	18 An operation research programme for future space requirement in the metropolis. Case studies of Delhi, Calcutta, Bombay, Ahmedabad, Bangalore and Hyderabad.	6.
	19 Use of air and underground facilities of large cities to meet the increasing demand for space. Use of fourth dimension in physical development.	2
	20 Intergovernmental fiscal relations between Municipality, States and Centre ; and Urban Development in India	5
	Projects on Urban Transportation (software, hardware) and Mass Transit : (Refer also to the Sector on **Transportation**)	
	21 Development of a **Centre for Urban Transportation and Road Safety** for R & D Work on Urban Traffic and Transportation Problems. Sponsoring and Coordination of RDD Projects. It would study :— 1. Travel Characteristics. 2. Transportation Systems.	50

1	2	3
	3. Trip Analysis.	
	4. Network Planning.	
	5. Design and Implementation.	
	6. Management.	
	7. Highway safety in mixed traffic.	
	8. Application of computer technology for simulation of heterogeneous traffic.	
	9. Capacity of urban road for mixed traffic conditions.	
	10. Mass Transportation Problems.	
	11. Transportation Technologies and their impact on Indian Cities.	
	12. Transport Systems for medium sized cities.	
	13. Comprehensive Transportation Planning.	
.G_2P_{22}	Systems Studies for Transportation in Kanpur Metropolitan Region.	1.50
23	Structuring Mass Transit Systems for the Cities of :— (See G_1P_3 also)	
	1. Calcutta	15.00
	2. Bombay	12.00
	3. Delhi	15.00
	4. Madras (See item P_{21} above)	8.00
24	Developing Software for Mass Transit Stations for Madras, Calcutta, Bombay, Delhi.	10.00
25	Impact of underground rapid transit on urban environment—Calcutta case study	2.00
26	Comparative cost benefit study of alternate modes of Mass Transit (Refer G_1P_3.)	
27	Organising an integrated inter-state and intra-city transportation structure together with coordinate movement systems for Calcutta, Delhi, Bombay and Madras	10.00
28	Overhead Pedestrian Bridges in metropolitan areas—software as well as hardware technology	5.00
29	Urban Transportation Management—Integrated Traffic and Transportation Authority. Development of alternate methods	6.00
30	Under-ground transportation for Delhi & Calcutta	
	(a) Identifying suitable comfort conditions for underground transportation system	6.00
	(b) Stream-lining operational management	5.00
	(c) Development relating to Structural, Soil Mechanics and Foundation Engineering ; Earthquake Engg. and construction problems, relating to underground mass urban transportation (Refer $S_{15}G_3A_2$ and $S_{15}G_4$ also)	15.00
	TOTAL $S_{15\cdot1}G_2$	505.50

G_3 : Planning Group on New Towns (including Industrial Townships)

5.$_1G_3P_1$	To identify criterias for locating new towns in the regional context of conservation of land as a resource; urbanisation strategy; balanced regional development.	10.00
2	Economics and environment of New Towns development in India (An empirical analysis evaluating alternative choices in development) (See also project $S_{15\cdot1}G_8P_4$)	12.00
3	Urban Ecology (To evolve and define the mechanism of urban areas in the context of new towns including relative effect of urban development on micro-climatic conditions of new towns.	8.00
4	Study of : Problems and prospects of housing, transportation and New Towns in the process of urbanisation.	30.00
	1. Evaluation of standards and operational efficiency of new towns established in post-independence era and formulation of standards for future new urban centres.	

1	2	3
	2. Programme location of new towns in selected regions within the process of urbanisation.	
	3. Urban Housing in the context of massive impending urbanisation.	
	4. Rural Housing and Village Planning; Sanitation as linked up with urbanisation and urban development.	
	The first phase will deal with :	
	(a) Locational and regional interaction.	
	(b) Conservation of resources in the region.	
	(c) Economic generation in the area.	
	(d) Socio-economic condition.	
	(e) Political, administrative and financial aspects.	
	(f) Extent to which rural migration has been arrested by the new towns.	
	The **second phase** would take into account design, planning and administration of new towns. Study of specific new towns by Roorkee University.	
	5 Comparative analysis of suburbanisation, new towns and urban renewal in the process of city growth.	1.0
	6 Study of Steel Towns around Kharagpur Area to havea National Feedback of Planning and Design of New Industrial Townships such as Purulia Alloy Steel Plant, Durgapur, Rourkela, Bumpur (Asansol), Bokaro Steel Town.	30.0
	Total $S_{15 \cdot 1}G_3$	91.0
	G_4 : Rapidly Growing Towns (other than metropolitan cities), Slum Improvement, Rural Development*	
$S_{15 \cdot 1}G_4P_1$	Studies of Slums and alternative solutions for needed improvements of environmental quality.	
	(a) Bombay Western Highway Slum Area (Santa Cruz to Mahim)	2.00
	(b) Calcutta (Bustee Improvement Schemes' Models)	2.00
	(c) Madras (Slum Clearance Boards' work)	2.00
	(d) Delhi (Jhuggi-Jhompri Scheme)	2.00
2.	Detailed Studies on Squatter Colonies and squatter zones.	
	(a) Bombay	2.00
	(b) Calcutta	2.00
	(c) Durgapur (Bena Chati and outer fringe area)	
	(d) Chandigarh (outer fringe area)	4.00
	(e) Other areas.	
3.1	System planning for the development of the slums on the basis of integrated strategy of metropolitan development.	1.00
3.2	Prevention of obsolescence (squatters and hawkers, etc.) on the pavements of urban areas.	0.50
4	A study of slums and squattering in selected 15 cities and rural areas of India. All-India and Region-wise coordinated projects.	80.00
5	Impact of Migration on Urban Growth and Development and its implications for Urban and Regional Planning (See G_1 in this sector.)	7.50
6	Rural Development Centre at IIT, (Kharagpur)* (A research cell located in the hearts of rural areas of the Eastern Region on rural development and housing).	25.0

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*Refer also to $S_{15}G_7$ on Rural Housing and Development.

1	2	3
7	R & D on Identification and Development of Market Towns for an aggregate of villages in various regions of the country (at least 5 centers).	30.00
8.1	Development of Community Structure Models on the basis of sizes and classes of villages (Rural Housing and Development).	1.25
8.2	Environmental Improvement in Villages around Auroville in Pondicherry, Anand (Gujarat), Shaktinagar, (Coimbatore) and 3 other typical Village Communities.	12.00
9	Development Potential of Backward Areas (Case Study of four districts).	10.00
10.1	Generating artificial land in hard core urban areas for rehabilitation and redevelopment (To decongest old cities, to identify areas of improvements and existing slum conditions, transportation networks, etc. by providing air-tight structure, above railway tracks & large scale public utility areas, etc.). The cities chosen are :	
	1. Calcutta	6.00
	2. Bombay	7.50
	3. Delhi	6.00
	4. Madras	5.00
	5. Kanpur	3.00
	6. Ludhiana	3.00
	7. Quilon or Alleppey	3.00
	8. Mysore	3.00
	9. Ahmedabad	3.00
	10. Jamshedpur	3.00
10.2	Urban Renewal (To evolve mechanism for the problems in urban areas involving public or private participation at the same time) Studies in Delhi, Bombay, Calcutta, Madras, Mysore, Kanpur, Ahmedabad.	6.00
10.3	To improve quality of deteriorating towns and cities like Agra, Varanasi, Hapur, Karnal, Rohtak, Bhapa, etc.	5.00
10.4	To evolve methods for the preservation of historic cities like Jaipur, Mandu, Durg, Fatehpur Sikri, etc.	5.00
11.1	Development of technology for Reclamation of Land in Urban Development . .	10.00
11.2	Reclamation and Management of Deralict Coal Mines and similar areas . .	4.00
12	Development of guidelines for project oriented Master Plans for small and medium-sized urban areas (20,00,000 population)* See also $S_{15}G_6$.	
	Total $S_{15.1}G_4$—	255.75
	G_5 : Public Health Engineering and Urban Environment*	
.1G_5P_1	Setting up of Institute for Research, Studies & Training in Environmental Systems (Research and Training Centre for urban and rural environment to solve problems of human settlement, environmental pollution and environmental appraisal of industrial projects)	25.00
	Water Supply (Including Water pollution)	
2	Drinking water supply in areas where only brakish water is available. (Budgetted for Rs. 25 lakhs in Panel on Environmental Quality, Sector on Environmental Aspects of Human Settlements; Group on Water Supply).	—
3	R & D towards development of Indigenous Low Cost Rainwater Catchment tanks for arid regions in India. State of Art of current practice of technologies used in the arid regions of the country. Application of innovative techniques such as excavated pit lined with plastic sheeting and a system of sand-cement filled polythene tubes to provide a revetment. Extensive Fields Studies in various parts of Country.	10.00

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*Refer also to Sector 18 on Environmental Quality, especially Group 1—Environmental Aspects of human settlements, sub-groups on Water Supply, Drainage and Wastes Disposal; Group 3—Environmental Pollution Control, Sub-groups on Water Pollution, Air Pollution, Noise Pollution.

Also $S_{15}G_5A_5$—Plumbing and Refuse Disposal Services in Buildings.

1	2
4	Storage tanks—material and capacity with special reference to prevention of corrosion in the coastal areas.
5	Explorative research regarding Plastic water tanks, Butyl Rubber water tanks, etc., for different capacities (for individual house, groups of houses.)
6	Standardisation of design and minimum thickness for circular distribution storage tanks of standard depth of two meters (a) brick masonery, (b) random ruble.
7	Indigenous chemicals for evaporation control of water storage.
8	Economics of different types and methods of drilling.
9	Studies on development of sturdy and pronomic hand-pump with minimum of repairs and maintenance/problems. Using :— (a) Ball bearing, cups of suitable material PVC for barrel etc. (b) Sealed units of hand-pump which do not need any priming. (c) PVC pipe casing as well as PVC strainers for economy and durability in small diameter tubewell. (d) Suitable taps on public standposts to prevent water wastage. (e) Prefabrication of and standardisation for rural water supply components.
10	Analysis and Optimal Design of Water Supply Pipe networks. Analysis of existing networks in various towns and cities to develop methods for augmentation caused by urban sprawl.*
11	Improvement towards accurate and sturdy water meters.
12	Cost-benefit studies on cathodic protection, state of pipe (old and new), size, quality of water and soil conditions to give guidelines when cathodic protection has to be/not to be provided.
13	Use of Plastic materials for pump casing, pump impellers, collapsible storage tanks.
14	Rationalisation of well construction methods, using chemically less susceptible material than brass or uncoated steel, (research on materials development)
15	Studies on development of Treatment Units including domestic filters for water supply from village water tanks and canals, for different regions of the country.
16	Indigenous/local filter media for standard/high rate rapid gravity filters.
17	Studies on treatment of water supply—Turbidity, Iron and manganese removal.
18	Studies on treatment of water supply—Development of (i) different types of compact (ii) Declining rate, filteration.
19	Improved charts in differential pressure chlorinators.
20	Development of measures and techniques to combat water pollution in *sources of water supply.*
21	Development of mathematical and physical models of circulation in relation to transport and dispersion of pollutants in estaries and coastal waters.
22	Studies in absorption and absorption of pollutants by sediments in suspension.
23	Model pilot project for assessing the demand and planning to maximise the use and re-use of water for various activities.
	Sewage Treatment Plants
24	Design of optimum thickness with and without coating to prevent corrosion in (i) the connecting pipes of sewage treatment plants (ii) Saline areas (iii) Femees (iv) sewage corrosion prevention methods for concrete sewers.
25	Studies of both biological and physical processes on the performance of various units in the existing conventional sewage treatment plants for arriving at rational design criteria for Indian conditions.
26	Innovation, Design & Evaluation of new techniques for sewage treatment e.g. oxidation ponds-field studies throughout the country, "Non-water" type chemical treatments.*

1	2	3
	Drainage and sewerage	
27	Use of alternate materials like AC/PVC for soil drainage including AC with indigenous asbestos fileres.	2.00
28	Manufacture of PVC Indian water closet with no splash, testing of prototypes. . .	1.00
29	Substitution of metallic systems for flushing systems, flushing pipes etc. by PVC . .	1.00
30	Standardisation of the minimum dia. of flushing pipe; minimum storage needed for flushing.	1.00
31	Development of flush valves to give discharges of one gallon and two gallons at a time (Dual water control for W.C.)	1.00
32	Further economy in water seal size for (i) hand flush and (ii) cistern flush. . . .	2.00
33	Ventilation and breaking of water seal—problems in single stack systems. . . .	1.00
34	Studies in the development of septic conditions in 3 or 4 hours of discharge for the house if master traps are omitted as per our general recommendations but objected to by certain corporations like that of Kanpur.	2.00
35	Septic tank design for economy and special use in congested areas.	2.00
36	Latrine design with regard to geometry of pits, their lining and adequate superstructure; typical designs for various areas of country.	0.50
37	Aerobic & Anerobic digestion of nightsoil for semi-urban and suburban areas. .	2.50
38	Improved methods of storage, collection and disposal of night soil, accumulation from dry latrines/sanitary latrines in the congested areas	1.00
39	Economical arrangements for disposal of night soil from railway compartments without spilling them on the tracks as at present.	1.00
	Industrial Waste Treatment	
40	Study on the use of the different industrial wastes for land irrigation and detailed compilation of the practice adopted in the country indicating the measures to optimise where necessary.	5.00
41	Study on utility and adoption of the following physico-chemical methods for wastes treatment (i) deep well disposal of intractable industrial wastes; (ii) removal of toxic and coloured materials by absorption an activities charcoal; (iii) submerged combustion for mineral bearing and/or cancentralised organic wastes; (iv) reverse osmosis for reclaiming water and valuable by-products.	10.00
42	Study on the use of soil culture and development of mutants for accelerating wastes treatment processes for complex wastes like pesticides, insecticides etc.	3.00
43	Reuse of sewage, effluents for air-conditioning, industrial cooling, flushing etc. . . .	1.00
	Air and Dust Pollution	
44	R&D towards combat and abatement of air and dust pollution in urban centres; case studies of metropolitan cities.*	10.00
	Noise Pollution and Urban Environment	
45	Develop a logistics for "Plant and Grow Trees" campaign for urban environment in various metropolitan centres*.	10.00
	Management	
46	Development of Strategies and Implementation Mechanisms for water and waste water management for the Indian conditions.	10.00
	Notes:—	
	Drainage and other sanitation aspects of slums and squatter settlements are dealt in Group 4 of Sector on Urbanisation.	
	Total S15.1 G5 . .	192.00

1	2	3
	G_6 : R & D on Social-Technical Aspects	
$S_{15\cdot1}G_6P_1$	**Census of Housing in Greater Bombay.** **Major Objectives :** To ascertain the number of dwellings, location, types, year of construction, construction material facilities, quality, tenancy status, occupant, etc.	3.00
2	**Housing Statistics on Continuing Basis in Greater Bombay** **Major Objectives :** To identify appropritate items on which information is to be collected and reported, and to devise appropriate proformas for reporting by public authorities dealing with housing and related issues (*viz.* Municipal Corporation of Greater Bombay, Registrar of Co-operative Societies, Maharashtra Housing Board etc.); To protest the proformas and suggest mechanics for collection of proforma data by a central unit; recommending legislative and/or administrative rules for collection and collation of proforma data on a continuing basis; and preparation of manual for collection, collation and reporting of data.	0.65
3	**Legislation, Rules and Regulations pertaining of housing construction, maintenance, tenure System and land use.** **Land Use Policies and Practices in Greater Bombay.** **Major Objectives :** To undertake a historical analysis of legislation and related legal and administrative actions to ascertain their influences on the housing situation, and suggest modification and/or new actions in the matter.	0.90
4	**Consumer Housing Preferences and Related Problems.** **Major Objectives :** To ascertain housing preferences of consumers in terms of design, type, space, tenancy status, location, facilities, etc. efforts made to obtain such housing economic and other problems faced in fulfilling requirements, etc.	0.60
5	**Comparative Study of Differential Housing Agencies, *e.g.* Public Sector, Co-operative, Promoter System etc. in Greater Bombay.** **Major Objectives :** To ascertain the extent of involvement and contribution of different agencies to housing, construction, the criteria used by different agencies in determining housing requirements, costs of construction for comparable housing and related issues.	0.60
6	**Characteristics of Townships.** **Major Objectives :** To study new townships being set up by statutory organisations *e.g.* CIDCO, with reference to factors contributing to the establishment of new township, criteria and assumptions in designing housing, problems in establishing the township, characteristics of the township in terms of residents, facilities, social relations, etc.	2.50
7	**Social Aspects of Housing, etc.** **Major Objectives :** To undertake comparative studies of different neighbourhoods (low, middle, and high social strata) in respect of neighbourhood patterns, community relations, family life in the context of housing and neighbourhood design, consequences of overcrowding for individual and family life, etc.	2.50
8	R and D on various aspects relating SPATIAL and SOCIAL factors in physical planning of settlements in various (projects to be sponsored in conjunction with Indian Council for Social Science Research and proposed National Board for Human Settlements and Physical Environment $S_{15}G_0P_1$).	10.00
	Total $S_{15\cdot1}G_6$.	20.75
	Grand Total For Sector on Urbanisation $S_{15\cdot1}$ G_0 to G_6 .	Rs. 18 crores

APPENDIX—III

HIGHLIGHTS OF SOME IMPORTANT PROJECTS*

etting up of a NATIONAL COMMISSION FOR BUILDING/CIVIL CONSTRUCTION :

It is intended to be an Apex Coordinating Agency/Commission for Civil Engineering onstruction Industry/(All India Council for Construction Industry). It may consist of Boards esponsible for coordinating in the following fields :

1. Materials of Construction (S_{18} G_1 P_1) . . .
2. Construction Equipment, Plants and Processes.
3. Construction Techniques.
4. Industrial Buildings.
5. Agreement Board for assessing and promoting innovative techniques of construction.
6. Construction Industry and Research Board.
7. Construction Industry Education—Training Board.
8. Construction Economics and Management Board.
9. Construction Practices and Administrative Reforms.
10. Extension Services in the construction industry.

Coordination, forward planning of input-outputs and integrated development of civil engieering construction industry is proposed to cover areas such as housing, institutional and ndustrial buildings, civil engineering construction for rural, urban and regional development. he coordination would be between central ministries (who are concerned with construction, roduction of materials, equipment plant and processes) state ministries, municipalities, builders ssociations, building materials manufacturers, professional associations, research academic instiitions, ISI, Planning Commission, and Deptt. of Science and Technology.

A note regarding setting up of the apex coordinating agency/commission is being prepared y the NCST. The total expenditure for the above agency/commission for the Fifth Five Year lan would be of the order of Rs. 250 lakhs (including that for materials of construction . . 100 khs).

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*Other projects as given in the List of Projects are self-explanatory and hence details not ppended.

MATERIALS OF CONSTRUCTION

Naional Agency or Commission for Materials of Construction

In order to ensure that the materials of construction receive due attention, a Natio Agency or Commission should be created solely to look after the interests of the nation wi respect to construction materials. This Agency or Commission could perform functio similar, for example, to those of the Ministry of Building Materials in the USSR but witho being a regular ministry or department of the Government of India.

This Agency or Commission will be responsible for all aspects of planning and developme so far as these relate to materials of construction. Thus, it would be the organ through whi the thrust in science and technology as well as thrust in industrial development will be give it will support the national planning activity and coordinate and monitor R & D. At the san time it would also perform the functions much the same way as the Steel Authority of Ind in the field of materials of construction for which there are no apex bodies coordinating inpu and outputs.

In addition to the forward planning of inputs—outputs to building material agencies, would do development research towards formulating norms for consumption/use of materia like cement and steel for various types of buildings and other construction for different clima regions of the country. It would provide basis for formulating policy decisions regarding forwa planning and development of building materials, promotion of new and substitute materials, a use of scarce materials like cement and steel for different types of civil engineering constructio

The estimated cost of establishing and running such an Agency or Commission in the Fif Five Year Plan period would be about Rs. 100 lakhs excluding the investments on productio distribution and marketing which will be discussed under the various building materials indiv dually. This is estimated to be doubled during the Sixth Five Year Plan.

Demonstration-cum-Training Centre for Production of New and Improved Building Materia

The Items for which Pilot Plants for demonstration of new and improved techniques a required are given below.

1. Plants for production of lightweight aggregates from:—
   - (a) Clay (bloated clay aggregates) at Calcutta, Kanpur, Lucknow, Bombay, Del and Agartala (6 plants).
   - (b) Blast Furnace Slag at Durgapur (One plant).
2. Ready-mixed concrete plants at Delhi, Bombay, Calcutta and Madras (4 plants).
3. Demonstration-cum-Training Centres for brick manufacture (24 plants) at Delh Calcutta, Bombay, Madras, Kanpur, Nagpur, Gorakhpur, Rai Bareilly, Amritsar, Rohta Ludhiana, Chandigarh, Ahmedabad, Bangalore, Hubli, Baroda, Surat, Indore, Hyderaba Cuttack, Gauhati, Durgapur, Vizag, Patna.
4. Clay Pozzolana Plants. 15 plants at metropolitan cities and towns.
5. Building Lime (dry hydrated lime plants). 10 Plants at metropolitan cities.
6. Integrated Plants for seasoning, preservation, treatment and joinery for secondary tin bers. 10 plants at metropolitan cities.

lopment work regarding production of new building materials/substitute materials plants

The following building materials industries are proposed by Ministry of Works and Hous- or Fifth Five Year Plan for which RDD back up is required :

1. Cellular Concrete.
2. Lightweight Aggregate.
3. Readymixed Mortars/Plaster (clay pozzolana, hydrated lime and gypsum plasters).
4. Readymixed Concrete (with/without fly ash).
5. Sandlime Bricks.
6. Structural Clay Products (perforated bricks, hollow clay blocks, roofing and flooring tiles etc., other than common bricks).

ks, Tiles and Other Clay Building Products

At present, the CBRI is one of the Institutes in the country actively engaged in research and lopment of clay building materials. NBO is actively engaged in promotion activity relat- to production of structural clay products. This could be expanded in terms of training rammes for brick kiln operators, helping in setting up of brick industries. sidering the fact that the brick industry is still run on a cottage scale and is largely depen- on primitive methods of manufacture, it calls for a very large effort in R & D if it is to placed on a scientific footing. A beginning has been made in the CBRI where over the decade several processes have been developed in improving the quality of bricks from rior grades of clay. Improved machinery and kilns have also been designed, developed and oduced in the market. Projects are also underway on the design and manufacture of new onry units such as structural clay products. A fully equipped pilot plant for test evalua- of clays has also been established. Special emphasis is given to development of these erials in rural areas.

Stabilized Products

All soils are not suitable for stabilization economically. Preliminary knowledge of soil perties and their laboratory tests are essential. This will need surveys, classification, and labo- ry tests. Following research and development work is necessary:

(1) Simple field identification and tests with special reference to stabilisation. If tests have already been developed, these have to be reviewed in the context of our own requirements.

(2) Determination of soil composition, type and proportion of various stabilisers. Evaluation of engineering properties of stabilised soils.

(3) Economical size and shape of blocks, bricks and other components. Construction methods, *e.g.* bond, mortar, fixing methods for door, window frames, fixtures, and repair and maintenance.

(4) Efficient and economical machines for pressing and moulding the blocks.

(5) Large scale field trials, extension work and dissemination of knowledge specially in rural areas.

R and D Centre for Lime and Lime Products

The R and D Centre on Lime and Lime Products could coordinate following pro that should be taken up most urgently:

1. Limestone Map

Preparation and publication of a map of India indicating the availability of different c of lime in the country for different end-uses with proper provision for deposits which will two or more end-uses. In the case of lime for building industry, the criterion will be the che composition of limestone. A request for preparation of the map should be made to the Mi of Mines. This map should be prepared as early as possible but may incorporate inform that is available up-to-date.

2. Lime Burning (Kilns)

It was decided to recommend development of a 100 tonnes lime kiln on the follo considerations:

(a) Design to be taken from foreign countries and modified according to Indian condit fabrication and production procedures. The Sub-Group felt that it is the right now to establish 100 tonnes per day lime kilns for manufacturing good quality at possibly reduced cost. It is noted that in other countries lime bu technology has advanced very much and now they are making lime kilns o order of 500 tonnes per day and so 100 tonnes per day kilns have become outm in those countries. In this context, it is further felt that for indigenous m facture of such high capacity kilns like 100 tonnes per day, two courses of a are possible. One is to import complete know-how with a view to saving time, the other is to initiate a R & D project in this direction in one of the laborat The time constraint on local development is considerable and it is desirable to into being the large capacity lime kilns within one or two years. So, at least te cal know-how for such a design may have to be imported along with drawings which could be later modified to suit local conditions. The *modus operandi* is left open. In this context, it is noticed that the present day capacity of indigen developed lime kilns is about 25 tonnes per day, except in some chemical indus where 50—100 tonnes a day kilns based on imported know-how are alread operation. It is felt that some of these 100 tonnes kilns existing in the cou could also be checked up to find out whether a suitable Indian design coul evolved.

(b) Develop technique/kiln for burning hydraulic limestone, which are widely di buted and can produce good hydraulic lime.

(c) Develop burning technique/kiln for the calcination of shell, raw materials for w are widely available in the coastal regions.

3. Alternative fuel for Lime Kilns

It is pointed out that with the present position of coal and its supply from diffe sources, it is likely that the proper burning efficiency of lime kilns may not be achieved. for larger kilns, alternative fuels other than coal need to be investigated. One of these could be use of gas generated from coal. The Sub-Group therefore recommended that R & D work be tiated and the technology of producing gas from coal for lime burning in vertical kilns, be veloped. In places where natural gas is available, technology should be developed for also.

nufacture of Hydrated Lime

is felt that centres be established in different parts of the country for the manufacture rated lime in conjunction with the kilns, so that hydrated lime could be easily available to s cities. In this context, it is recommended that R & D effort may be considered with administrative procedures for establishing centres of hydration.

velopment of suitable equipment for manufacture of Hydrated Lime

Vhile small capacity hydrator know-how is available in the country, the same know-how ave to be developed—or foreign know-how obtained—to match the capacities with 100 per day kilns. The development of the dydration techniques could be along three direc-

(a) For high calcium lime;

(b) For high magnesium lime; and

(c) For hydraulic lime.

ilisation of Wastes

To develop suitable methods and techniques for utilising waste products for the manufac- f building materials/mortars through R & D efforts. Some of these wastes are as follows:

(a) Lime kiln waste;

(b) Carbide lime;

(c) Sugar factory lime sludge;

(d) Steel plant sludge; and

(e) Fly ash.

velopment of lime-based ready-to-use products

(a) Building units;

(b) Ready-mixed mortars;

(c) Ready-mixed plasters; and

(d) Dolomitic lime-based products.

t is noted that blocks, mortars, plasters etc. can be made from lime and other materials, fly-ash, cinder, pozzolana, sand (lime-sand bricks). Similarly, dolomitic lime can find rous uses in building construction. It is, therefore, felt that thorough investigations be d out to make units or mortars or plaster with other available materials as lime-based cts.

cking

n order to preserve the quality of lime and to make handling easier, it is felt that a R & D t be carried out to develop a sturdy, yet economical packing for lime.

R and D Centre for Asbestos Products:

R and D Programmes.—The following R and D Programmes are suggested :

1. Finding out the know-how on the manufacture of AC products which are still b imported, such as electric arc and heat resisting boards, etc.
2. Use of cheaper grade of imported fibre.
3. Possibility of use of indigenous fibre.
4. Diversification of products etc.
5. The Cement Research Institute of India and Central Building Research Institute assist the industry in problems connected with the utilization of cement in its pre available forms or in any other blend or mixture which could suit the industry fit within the country's overall availability of this raw material.

R and D Centre for Gypsum and Gypsum Products

Total work envisaged:

(a) Setting up of plants for upgrading low grade gypsum.

(b) Development of gypsum-based materials as enumerated below:

(i) Manufacture of sulphuric acid and cement from gypsum is an established indus in U.K., Austria, Poland and other European countries. The industry invo high capital cost but the process is considered economical in view of the fact high quality cement clinker is obtained as a by-product.

(ii) A wide range of products based on calcined gypsum plaster have been develo and are being manufactured abroad. They include different types of pla boards, panels, precast reinforced slabs, special types of acoustical and fire res ing premixed plasters, acoustic tiles, blocks for partition walls, solid precast inforced plaster walls, gypsum sheeting etc. Their use in building construct is popular on account of their lightness, fire resisting and thermal insulating p perties, decorative effects, speedier construction and saving of labour at the si

(iii) Gypsum glass fibre reinforced composites.

Research Problems for the Fifth Five Year Plan

1. Beneficiation of low grade gypsum from different sources—methods, their practicabi as per local conditions and economies.
2. Benefication of phospho gypsum.
3. Utilisation of beneficiated gypsum.
   (a) as an additive to cement clinker.
   (b) for the manufacture of ready mixed plasters, plaster boards, insulating and acou tile, walling units, glass reinforced load bearing components such as floors, pa tions etc.

Sub-sectoral Science and Technology Plan for Gypsum

In view of the shortage of conventional building materials and the increasing demands meet the requirements of the building industry, it would be desirable to develop new materi to augment the supply of conventional material. Since gypsum is available in large quanti in the country and the calcined material has cementatious properties, it would be desirable develop new materials as pre-mixed plasters, plaster boards, panels, precast reinforced sla blocks for partition walls, solid precast reinforced plaster walls, gypsum sheeting etc.

d D Centre for Plastic Products for Civil Engineering Constrcution Industry.

Facilities for research and development in polymer exist in a number of national labora-s, research institutions, universities and technological institutions in India. Some industries have this facility.

Many institutions are willing to undertake applied research and development work in this . The sub-group is, however, of the view that a Plastic Research Centre be set up with ucleus at Baroda. Indian Petro Chemicals Ltd. are setting up research and development ities at this place. It is only logical that such a centre for applied research in building ication be set up at this place as well. The following considerations weigh in favour of ng up an Institute at this place:

(i) Plastic raw materials and utilities will be available nearby thus reducing the cost of research.

(ii) Help of highly qualified and trained staff in the field of petro-chemicals and plastics would be available at this place.

(iii) R & D wing of IPCL could be in a position to develop new composition of polymers to suit the requirements in building application and would thus be a great help to this centre.

(iv) A research and development organisation in the field of processing machinery is also being proposed to be set up as a cell of IPCL at Baroda.

The objectives of this Institute would be:

(a) To formulate a suitable plan for research and development of new plastic materials.

(b) To locate new outlets for use of plastic materials in building construction.

(c) To carry out programmes for research and development and specific applications in the building industry.

(d) To coordinate the programme of research with the processing units and plastic material manufacturers.

(e) To collect statistics, scientific and technical information from research laboratories abroad.

(f) To collect statistics, scientific and technical information and to disseminate information to NBO, ISI, testing laboratories and other research institutions such as S.R.I., N.C.L., etc.

(g) To set up a library on plastics and a documentation centre for propagation of the R & D work done to the industries.

Thus the Plastic Research Centre for construction application would work as a brain ntre for Research and Development in this field and would sponsor/coordinate RDD work h other institutions. NBO would take care of the extension activities and promotion of the use plastics in building construction.

At present there are a number of manufacturers of plastic raw materials in the organised tor. Some of them have facilities for research and development work for the processing of stic materials. There are a very large number of manufacturers in the small scale industries. ese manufacturers do not have facility for the research and development work. They have form- an All India Plastic Manufacturers Association which functions from Bombay and an Indian

Plastics Federation which functions from Calcutta. Their main aim is promotion of trade an they have not taken up any development activity so far. The manufacturers can look afte their technical and commercial interests only if they join together and assist the Governme in the development of the Plastic Research Centre on a cooperative basis. This would enab them to participate on an equal footing on the deliberations and the work to be taken up at th research centre. They would, this, also be able to utilize or commercialize the developme work done at this centre on a mass scale without creating monopolies.

R and D Centre for Glass and Ceramics Building Products.

Regarding major R & D Programmes, their impact and the thrust in S&T areas, it is f that the following R&D be attempted:

(a) Major Raw Materials—China Clay, Plastic Ball Clay, Felspar and Quartz.

The requirements of plastic clays and china clays are likely to outstrip the availabili from the limited sources known at the present. One of the main projects will be to develo locally available raw materials as substitutes for the ball clays and china clay. Due to lack research work it is not yet appreciated by the industries that cheaper and locally available ra materials with or without beneficiation can be incorporated without any adverse effect on t quality of the final product manufactured. They have been generally tied down by trad tion, and use of traditional raw materials of such regional resources will not only make availab cheap raw materials to the industry, provide employment opportunities to local people in the areas, reduce the strain on the already strained transport resources, but also permit continu expansion of the manufacturing capacity to meet the increasing demand of the building materia such as sanitaryware and tiles. Places for supply of traditional raw materials are situated f apart such as Rajasthan, Andhra, Saurashtra, Kerala, M.P., Bihar and West Bengal. Sin most of the traditional bodies use traditional raw materials which are to be carried over lo distances, the need is felt for development of regional resources, where necessary, by ma ing a break from traditional sources of raw materials, and by developing new bodies utilizi regional raw materials.

(b) Development of fast firing clay bodies and glazes

Any break-through solution in this field would enable considerable increase in produ tion in the existing units involving only negligible investment, if any.

(c) Development of fast firing techniques

This involves research in furnace design apart from the use of the fast firing bodies ar glazes. This will help in additional production, without any extra appreciable investment.

(d) Development of low expansion glazes maturing at high temperature, medium temperatu and low temperature. This exercise is inter-related with development of fast firing clay bodi glazes and firing techniques keeping the dead losses from rejections low.

(e) Development of lead boron free glaze and low zinc glaze

This will help to reduce the consumption of imported materials such as lead, zinc, boro etc.

(f) Extension Work

Development of body composition and firing techniques for manufacture of other utility wa enabling the local tradesmen to become entrepreneurs with good prospects.

At present the CGCRI is the only major laboratory in Calcutta connected with Glass and
amics essentially. With the development of local raw-materials and also for extension work, it
ecommended that regional ceramic laboratories be established at the following places:

1. Ahmedabad.
2. Bombay.
3. Bangalore and Mysore.
4. Delhi.
5. Madras.
6. Hyderabad.

These research laboratories will primarily carry out the analysis and routine tests and until
h time that they can be equipped with more sophisticated equipment, one of their scientists
go to a more advanced laboratory, such as CGCRI, for advanced work. It will also be
ferable to have a geologist attached to each of the laboratories, for investigating the required
materials resources and keep liaison with the department of Geological Survey of India.
e capital cost for each regional laboratory will be Rs. 4 lakhs for initial equipment, land and
lding, and recurring Rs. 1 lakh.

A part of the cost of establishing regional laboratories and thereafter most of the cost
ards recurring expenses for running the laboratories, can be met by Central Government
lecting cess of, say, one percent on the turnover of the manufacturing units and re-allocating
same to the regional laboratories in those areas mentioned, in the same proportion in which
s is collected.

There has been a general complaint that the small scale sector are unable to have their
shed products tested. The regional laboratories can cater to their requirements on payment
a charge or if they may so desire, they can also become members by payment of cess.

CONSTRUCTION EQUIPMENT

istruction Equipment Cells/Divisions for Research, Design and Prototype Development.

The research and development effort in construction tools, equipment, plant and machinery
dentified as one of the major lacunae for which dependance on foreign equipment, plants
processes has not been always geared towards development of appropriate technologies for
country. In many cases because of lack of infra-structure by way of R&D centres/divisions/
s engaged in continuing development efforts in this area to a sufficient level, and equipment
a-structure (design and production expertise) only, full-fledged complete processes have been
orted e.g. Siprox, Spiroll, Pipe Manufacturing Plants, Sleepers, etc. This is a big gap in
elopment of building materials and component processes. Simultaneously with Building Mate-
s/Components Development Programmes in Fifth Plan, the development of construction
ipment, plant and processes deserve priority as a necessary infrastructual development. For
. it is proposed that CBRI expand significantly its division on Building Plant, Productivity and
cesses and that CMERI, MERADO have a full-fledged division for development of construc-
equipment; the CSIR complex at Madras to develop equipment for Partial Prefabrication by
pting a multi-disciplinary approach with collaboration of SERC, MERADO and other regio-
laboratories in the above complex. Academic institutions are identified for undertaking deve-
ment work on instrumentation, light construction equipment.

R and D in academic institutions on Light Construction Equipment.

The following areas relating to design, prototype fabrication of light construction to testing equipment, requiring multi-disciplinary teams are proposed:

1. High frequency equipment for drills, winches, vibrators.
2. Electronic equipment for testing.
3. Structural testing.
4. Hydraulic (higher pressures) testing.
5. Control and testing equipment for supervising construction (non-destructive tests hammer rebound, sonic, etc), for construction machinery.
6. Light and sophisticated equipment, tools for testing in the field of construction.
7. Fatigue reducing tools for increasing efficiency and productivity.

R and D towards Construction Equipment for Site Clearance, Excavation and Foundations.

The projects identified are :

1. Application of hydraulic systems for operation and control for replacing the mech nical controls in such equipment such as excavators, cranes, tractors, trenchers, e
2. Development of hydraulic systems. Basic technology for hydraulic controls to developed including circuit design, design of elements constituting the circuit, a characteristics of fluids.
3. Petrol driven portable rock drills, to replace those driven by compressed airs. This especially useful for operating in remote areas.
4. Heavy pilling hammers, air and diesel driven, to be developed which could mounted on rigs available in the country.
5. Vibratory and sonic pile driver.
6. Concrete pump.
7. Application of high frequency equipment for drills, pile hammers, pumps.
8. Vibrofloatation and vibro-replacement equipment for improving load bearing cap city of weak soils.
9. Petrol driven soil tampers to improve soil compaction in restricted spaces.
10. Pneumatic tyred wheel rollers for internal roads and compacting soils through ad quate pressure.

The above projects help import substitution and improve construction practices cons derably.

Construction Equipment for Conventional Bldg. Methods (excluding foundations).

The projects proposed in this sub-group include :

1. Vibratory damp proof course compactors—Trowel vibrator is preferred compared the present form of a needle, screen or platform vibrator for damp proof course

2. Brick conveyors, stone block conveyors—a conveyor chain with suspended grabs would be especially helpful in multi-storeyed construction.
3. Plaster guns with or without rotary trowels would help in reducing wastes in mortars.
4. Ramer-in-fasteners for fastening doors and windows to masonry or concrete, pelmets, fan hooks, towel racks, sanitary ware.
5. Concrete pumps, concrete chutes will reduce cost of transporting concrete by 50 per cent in urban areas; use before concrete sets.
6. Equipment for washing sand and aggregates.

uction Equipment for Partial Prefabrication including Concrete Precasting Factories.

e of the important projects identified are :

oduction/Fabrication Equipment

1. Ready mixed concrete trucks especially in metropolitan areas, and for utilising flyash efficiently.
2. Pipe making machinery including moulds.
3. Medium capacity concrete batching plant.
4. Concrete cutting machinery.
5. High frequency external vibrators for high strength concretes.
6. High pressure hydraulic jacks of capacities from 30 tonnes to 200 tonnes.
7. Concrete tile manufacturing machine.
8. Coil straightening machine.
9. Reinforcing cage bending machine.
10. High pressure mould cleaner.
11. Torque multiplying/limiting spanner.
12. Thin vibrator shafts.
13. Concrete block making machine including continuous block making.
14. Various formwork systems.
15. Extruding machines for cored slabs or strip slabs, on long assembly with or without prestress.

andling and Erection Equipment

16. Small mobile cranes.
17. Lifting beams and slings.
18. Light-weight derrik poles.
19. Light weight working platforms (hydraulic).
20. Light weight floor hoist machines.
21. Modified wheel barrows for Indian conditions.

C. Accessories and Aids for Construction

22. Joint sealant pumps/guns.
23. Suspended climbers in tall buildings.
24. Safety belt for workers.
25. Holding down devices, bar splicers, spacers and binders.
26. Admixture dispensers.

D. Testing and Control Equipment

27. Test cylinders capacities of 0.25 tonnes to 200 tonnes; static and dynamic.
28. Long travel high precision dial gauges.
29. Contact type strain measuring mechanical gauges with adjustable gauge lengths.
30. Mercury capsules for calibrators (for load applying/measuring devices).

Construction Equipment for Full Prefabrication

The important projects include:

A. Manufacturing Equipment

1. Moulds making (of various types for different purposes—plain, tilting, collaps mould; battery type block making etc.).
2. Special prestressing equipment.
3. Curing equipment.
4. Demoulding, cleaning and sizing (stacking) equipment.

B. Transportation and Handling Equipment

5. Tower cranes (annual capacity 50 numbers).
6. Spreading beam for panel handling.
7. Vacuum pump.
8. Vacuum pads (annual demand of 50 each—5 to 8 are for handling of prefabrica elements in factory).
9. Transportation of prefabricated elements from factory to site.
10. Equipment for erection and assembly.
11. Ancillary equipment.

"TYPIFICATION" ORGANISATION FOR INDUSTRIAL BUILDINGS

oftware Design and Development. Standardisation of research results in a readily useable

ts. 85 lakhs has been earmarked for this project for 5 years.

'here is an urgent need to standardize spans, column-spacings, heights and roofing schemes ustrial and institutional buildings. Standardization of industrial buildings and its effective nentation will be possible only if a Typification Organisation is established. This is the ery" mechanism for incorporating research into actual practice by developing and trans- research in a readily useable form through design aids, type designs of industrial structures all details for manufacture/construction; explanatory handbooks for use of above data, ig programmes.

One of the main objectives of the Typification Organisation is to evolve optimized standard ural designs which can effectively save scarce materials such as steel and cement. This iisation in carrying out this responsibility will function in the same manner as the NIIZHB, ZT and CHIPEIPB in USSR.

New techniques evolved as a result of R & D activities will be incorporated into standard ium designs evolved in consultation with the user agencies for different types of industrial ngs. The problems that arise in actual practice in using the standardized designs will also udied for incorporation in type designs for continuous updating, for different types of in- ies, for various climatic regions of the country.

Typification of precast units is the process of selection of the most favourable alternative ach of the constructional elements of the building. In comparison with other alternatives, it possess the best technical and economical indices to achieve :

(i) minimum consumption of materials, especially steel.

(ii) the most suitable weight according to the conditions of manufacture, transportation and erection.

(iii) the lowest cost.

(iv) Development of precast concrete component industries in various regions based on standardised designs, instead of structural steel for light and medium size industries for their factory buildings.

The Typification Organisation contemplated here will help in achieving the above objectives.

STEEL STRUCTURES RESEARCH COUNCIL

This is for promoting optimum use of steel through R & D projects, better design techniques. nsion services, design aids, design handbooks. This may be based at SERC, Roorkee, in unction will SAIL, steel fabricators, academic institutions. Specific projects of immediate could be sponsored to universities, IIT's and research institutions.

The objectives of the Council would be as given below:

1. Preparation of a handbook for general structural steel design (Similar books are extensively used in U.K., U.S.A., Canada, Belgium.)
2. Study of the design and fabrication of tapered members.
3. Study on castellated beams.
4. Development of open web joints.
5. Use of plastic design for industrial buildings.
6. Design and construction of cable roofs.
7. Standardisation of small capacity mill building bents.
8. Study of secondary stresses and deformations due to welding.
9. Handbook for design of welded joints.
10. Study and development of high friction grip bolts.

Shortages in steel are expected to continue, at least for the next 10 years. Hence it is necessary to use the latest methods of design construction and fabrication, for saving steel. It is estimated that upto 25% steel could be saved through rational design. India's steel production is about 6 million tonnes while the requirement by the end of Fifth Five Year Plan is around 18 million tonnes. Most countries have an Institute for Steel construction which has a research Council.

The total amount needed for this project is Rs. 100 lakhs for 5 years.

WATER SUPPLY & SANITATION SERVICES IN BUILDINGS

The objectives of R & D work would be :

1. To try new materials like P.V.C. and high density polythene;
2. To develop suitable fixtures and fittings and jointing procedures with use of r materials;
3. To develop procedures for design of distribution and collection systems of water waste water so as to achieve economy;
4. To develop suitable small capacity, low cost water treatment units, suitable for use different types of buildings, in different locations;
5. To develop suitable low cost waste treatment units so as to achieve reuse of wastes
6. To study the air pollution problems connected with buildings and suggest reme measures;
7. To study in an integrated fashion, different problems of high density buildings suggest suitable approaches in achieving efficiency and economy in different types services needed by such buildings;
8. To study environmental conditions of the railway platforms and bus stations, and suggest suitable design and treatment procedures for collection and disposal wastes of these places;
9. Strengthening of RDD Centres on rural water supply and sanitation.

In a building complex, proper design of water supply and sanitation services is of utm importance. The total expected plan outlay in different types of building services in the F Five Year Plan is of the order of Rs. 2,000 crores. Many existing building complexes are experiencing considerable inadequacy in this regard. Hence any improvement or econ achieved in providing these services will have a significant impact. The sanitation facilities at shelters and railway platforms are far from satisfactory and these places serve as dis nission centres. Hence, they need immediate atteniton. It is almost axiamatic that the l growth and development of the community is greatly dependent upon these services and as he research carried out on the above topics will find immediate application in the nationng process.

URBAN HOUSING AND PHYSICAL PLANNING

ardisation and Modular Coordination

The purpose of this project is to identify those components (both physical and spatial) of ntial buildings which can be standardised, either on regional level or at the national level the view point of user needs, materials availability, climatic regions etc. Simultaneously, tages of modular coordination shall also be evaluated and developed so that it can be inrated into the process of standardisation. The basis would be a study of mass urban ng projects for the last 20 years in different parts of the country.

Standardisation of building components and spatial units, if brought into actual practice, ring about substantial technological and economic advantages. It will also encourage speedier erial production of buildings.

Introduction of the standardisation idea for building components and spaces is likely to take derable length of time in context of the current state of our building industry. If adequate ts are put in this field and all reasonable measures taken for its wide-spread use, economic fits are most likely to become apparent during the Sixth Five-Year Plan period.

Research in this field should be carried out by various governmental and private agencies ltaneously, each agency dealing with a selected few aspects of the problem. An Advisory d could coordinate activities of different agencies and after the R & D work has progressed ciently, Indian Standards Institution could take over the task of implementation into draft dards and encouraging wide application into practice. For this, the National Buildings Orsation could play a coordinating role and house the secretariat for the Advisory Board.

elopment of a Hand-Book for Urban Dwelling Designs

The objective is to collect, in the form of a hand-book all available information relating welling designs (spatial, physical, structural, construction details). The information shall on those social, cultural, technological (various architectural, engineering fields including ronmental physics), ideological, legal, economical as and financial aspects which go into lling designs.

Such a hand-book would provide comprehensive information to all designers, builders individuals/housing society's members, and thereby increase the savings in or rationally se spaces which are allocated for different activities, in wastage of building materials, vell as help in making dwellings more efficient from functional as well as climatic (environtal) view points. Experts from various agencies/departments would be commissioned to e different chapters, with the main coordinating role with the National Buildings Organisa-
.

The tangible advantages shall become apparent as soon as such a handbook has found e circulation. It is envisaged that the social and techno-economic advantages of the efforts his direction shall become available in the second half of the 5th Five Year Plan.

Structural Design of Lintels, Roofs and other Components of Mass Urban Housing Projects.

Objectives of this proposal are the assessment of technology in practice vis-a-vis curr
Indian standards and thereafter developing more economical designs of lintels and roofs. Also,
develop norms for rational usage of steel and cement, for use by steel controller.

Based on sample survey of mass housing projects by housing boards and developm
authorities, it has been shown by SERC, that even with respect to 1964 Code of Pract
wastage in steel ranges from 20 to 50 per cent and in cement from 15 to 25 per cent. I
quite likely that with respect to research results, the wastage would be even more. Tech
economic merits of this project lie in its potentiality to reduce the wastages.

Tangible benefits from this project shall become apparent as soon as the new desi
are communicated to, and accepted by, design and construction agencies.

Study of Human Settlements, their Sizes and Locations

One objective is to make studies for evaluating "optimum" size of human settlements
sufficient concentration which would, besides conserving land and maximising its use, m
possible for provision of community facilities at lower per unit cost without reducing the qua
of life. Another objective of this project is to study spatial location of economic and so
activity throughout the region for villages, market-towns, intermediate towns and cities form
a continuum.

Techno-economic merits of this project lie in its potentiality to provide the necessary ba
ground data for rational decision-making in reference to the details of a future urban policy.

Socio-economic benefits from this project shall be available only in the long-term and s
continue in the coming Five-Year Plans.

Agency for Large-Scale Experimental Construction for Urban Housing

Research and development activities, though a backbone of the national progress,
not sufficient *per se*. It is the large-scale application and institutionalisation of their success
results which is responsible for actual development. Keeping this in view, establishment of
agency or large scale experimental construction of dwellings throughout the country has b
proposed. (The impact of "school buildings" project and their large scale application of te
nology into actual practice, show the way for intensive use of available knowledge to so
social problems, at the same time having large scale experimentations which can effect eco
mics). This agency, together with its regional centres, would require Rs. 20 lakhs for
establishment and functioning. Furthermore, it is estimated that an additional sum of Rs.
lakhs would be required by this agency as expenditure on field-testing, field-establishment a
site supervision of experimental projects.

This project is complementary to the scheme of NBO to promote experimental construct
to try out new ideas and technological innovations on a small/medium scale on various ty
of buildings. The successful results of these projects may be developed for use in the large sc
experimental building agency for urban housing.

strial Buildings

The Planning Group on Industrial Buildings is making a detailed plan in respect of the wing broad headings in conjunction with other planning groups which deal with Structural ign, Foundation Engineering, Services in general.

(1) Physical planning of various industrial complexes. Norms for spatial planning. Planning standards for industrial buildings for functional efficiency. Location planning. Identification of major types of industries.

(2) Efficient plant lay-out using ergonomic principles. R & D requirements on lay-out planning.

(3) Structural designs. Identification of various building schemes suited to industrial structures. Standardisation and typification of building components and foundations. Construction techniques. Standardisation of structural components. Typification Organisation for putting results of research in a readily usable form.

(4) Construction planning and management.

(5) Environmental control—heat, lighting, ventilation, acoustics, sewerage and drainage. Pollution effects—environmental and on workers.

(6) Maintenance and maintenance management.

(7) Re-use of industrial water & waste. Effluent disposal.

search, Design, Development on Various Types of Institutional Buildings

a. Physical planning including efficient lay-out using anthropometrics of Indian subjects d ergonomics principles to individual buildings and complexes of such structures. R & D icerning norms for spatial planning. Identification of needed surveys to get feedback from esent practices. Assessment of needs and costs of various types of institutional (including ictional buildings) in the Fifth Five Year Plan. Development of scientific basis for planning physical environment, R & D surveys, design aids, evaluation machanisms, etc.

b. Structural and foundation design, construction practices, maintenance management, ndardisation & typification.

c. Services and environmental control; natural and artificial light, air, humidity, heat, und, radiation, earth-quake, sewerage, drainage, energy, biological pesticides, pollutional e control. Sanitation facilities, general cleanliness, facilities required for individuals and ciety connected with the institution. Maintenance management, influence of institution to rroundings, and influence of surroundings to an institution. Life, quality and maintenance institutional buildings.

d. Costs-initial, Costs-in use. Economics of institutional buildings, including methods for hieving economics through rational planning, design, construction techniques and maintenance ethods; for functional performance and environmental facilities.

evelopment" Groups for classes of institutional buildings to be set up in order to get a mprehensive Science and Technology Plan in the area. The aim is to provide economically. stitutional buildings of various types, to suit different functions efficiently by application and velopment of software (planning criteria, design, maintenance planning) and hardware onstruction technology etc.) by strengthening existing agencies doing R & D, extension rk, or by creation of new agencies.

CONSTRUCTION PRACTICES, PRODUCTIVITY AND MANAGEMENT PROJECTS BY NATIONAL BUILDING CONSTRUCTION CORPORATION LIMITED

(Public Sector Undertaking, with Ministry of Works and Housing, Government of India); 15 Lak expenditure for 5 years period is envisaged.

R and D, Data Collection etc. on the following topics, to be carried out in the NBCC.

1. Building construction practices including modern management with special reference to t application of CPM, PERT techniques in construction, planning and manageme suited for Indian conditions.
2. Quality control and case study of construction work, resulting in construction economi
3. Incentive for better production in construction work. both at supervisory and manageme level.
4. Labour welfare and prevention of accidents.
5. Research for manufacturing and envolving new products in the mechanised brick factor specially with regard to manufacturing of modular bricks and ceramic products, as well standardising in the manufacturing of bricks, such as introduction of modular bricks et
6. Conduction of research and setting up of plants for replacement of scarce buildi materials, such as cement, bricks etc., for residential complexes by more freely availab materials like lime, surkhi, cellular concrete blocks etc.
7. Certification of artisans and improvement in their productivity, in different fields of build ing practices.

INFORMATION AND DOCUMENTATION: NATIONAL INFORMATION SYSTEM FOR SCIENCE AND TECHNOLOGY

I. *Information Base for Integrated Development of Rural, Urban and Regional Systems*

1. Land Use Survey Data.
2. Materials, Resources and Geo-technical Data Base.
3. Socio-economic Statistical Data on
    - (a) Housing.
    - (b) Transportation and Communications.
    - (c) Utilities, Water Supply, Drainage, Sanitation, Gas, Electricity, etc.
    - (d) Environmental Quality-Sanitary Engineering, Public Health Engineering, Waste Dis posal and Recycling of Wastes.
    - (e) Other Urban Services.
    - (f) Data regarding Industries.
    - (g) Demographic Data for Planning.

II. *Construction Industry Information Systems*

1. Building Materials Data Bank with Regional Centres.
2. Building Techniques Data Bank (costs, technical effectiveness).

3. Construction Industry Data.
4. Data on Construction Statistics and Housing Statistics.
5. Development and operation of Information Data Bank regarding efficiency of buildings from climatic and functional view points for heat, light, ventilation and sound for
   - (a) Industrial Buildings.
   - (b) Institutional Buildings.
   - (c) Office Buildings.
   - (d) Residential Buildings.
6. Data regarding Transportation, Irrigation and Power, and Industrial Products.

Data Bank regarding all the wastes, their quality and quantity, and their use throughout the country in *the areas of agricultural, animal, mineral, industrial. Community wastes and their usage or development into buildings materials, fuel sources, etc.*

ARGE SCALE EXPERIMENTAL CONSTRUCTION USING PREFABRICATION TECHNIQUES

search, Design, Development and Mass Scale Field Experimentation Project in prefabricated ystems of construction, proposed to be carried out by HHF for Mass Housing Projects in Metropolitian Cities (such as Delhi).

ject : is to develop and apply various levels of prefabricated technologies to large scale construcion and to try them in the field and contiually modify them based on field tests. 750 houses re to be constructed in three stages with the field application of different types of experiments. The construction at one stage will be subjected to critical evaluation from all points of view nd the experience will be incorporated in the following stage of the construction.

e success of the exercise will be a major turn in the construction industry. The changed pattern n turn will tentamount in considerable savings in internal resources like cement, steel etc. nd have spillover technological benefits to other construction.

t of the expenditure of 3.272 crores, Rs. 2.10 crores worth will be the value of the housing comlex which will be constructed during the research project. The complex can be used for the egular needs of housing. As such, the extra sum required is only Rs. 1.172 crores. The proect has a potential employment for 400 numbers per year.

llover of technology:—The technology will be useful for entrepreneurs throughout the counry. The precast components will be manufactured in the small scale industry and thus it vill create employment opportunities for millions of workmen in the factory—like job conditions gainst those in conventional buildings industry prevailing at present.

ers : The innovation of the research will be of national importance and will be permitted to be sed by government organisations and the construction industry as a whole. The greater se of the development will be to the benefit of the nation.

DEVELOPMENT WORK BY HOUSING AND URBAN DEVELOPMENT CORPORATIO

(Public Sector Undertaking, with Ministry of Works and Housing, Govt. of India)

(An investment of about 2½% on R & D especially relating to development of technology, duri the Fifth Plan is recommended).

1. Creation of an R & D liaison cell with specialists in various aspects to liaison wi CBRI, SERC, NBO, academic institutions (engineering colleges, IIT, IIM)which may se as secretariat of Scientific and Research Advisory Committee of HUDCO, in additi to existing technical cells (including information wing).

2. Sponsoring Studies on.

   (a) Socio-economic aspects.

   (b) Customer Preference Feed back (user surveys) of housing colonies.

   (c) Techno-economic feasibility studies on plants, processes for building materials, inclu ing suitability of new and substitute materials.

   (d) Investment on development of construction tools and machinery to save fatigue, crease quality and productivity, and their use in large scale housing projects.

   (e) Rational specifications to save costs.

   (f) Development of design handbooks, criteria for rational use of materials through i proved design techniques. For example, studies on designs made by state housi boards show that over-use of steel from (20—100%) and cement from (15—30%) in t design stage is found, even with regard to IS 456-1964 code of practi (Development contracts to prepare the design handbooks for roofing slabs etc. SE, RC, CBRI, CRI, IIT's etc. need to be done for different regions of the countr

   (g) Use of improved design techniques potential for large housing projects, to take a vantage of scale. (Development contracts with SERC, IIT's).

   (h) Use of modern methods of construction planning, for Indian conditions.

   (i) Development of systematic methods, for economic maintenance and manageme

   (j) Studies on economics of housing, technical, social, economic, administrative, financ inter-linkages.

3. Subsidy to State Housing Boards which take substantial loans from HUDCO, to have R & D liaision cell headed by an R & D oriented technical person with design constr tion experience of a level of S. E. This cell would have objectives similar to (1) a (2) above but at a state/regional level to take care of regional, climatic material resour social and economic conditions. (To sponsor studies in the local engineeri colleges, IIT's and other research institutions of problems of interest to the St Housing Board).

ELOPMENT PROJECTS BY INDIAN STANDARDS INSTITUTION, MINISTRY OF INDUSTRIAL DEVELOPMENT

ST OF EXPLANATORY HAND BOOKS AND DESIGN AIDS, TO BE PREPARED:

Construction Machinery (Already under preparation : estimated about Rs. B lakhs).

1. Planning, Design, Construction and Maintenance of various topics of buildings according to National Building Code......A whole series of handbooks on the same.
2. Unified Concrete Code (unified approach to structural concrete-plain, reinforced and prestressed):
   a. handbook.
   b. design aids.
3. Explanatory handbook for earth-quike resistant construction of buildings.
4. Explanatory handbook for loading code-loads on structures.
5. Handbook of Concrete (materials, preparation of concrete, design of concrete mix etc. and concrete structures).
6. Masonry Handbook ...Engineered masonry structures including reinforced brick-masonry.
7. Cellular or Lightweight Concret Handbook.
8. Pipe Handbook.
9. Reinforcement Handbook.
10. Fire Safety Handbook.
11. National Plumbing Code.
12. Water Treatment and Sewage Treatment Handbook.
13. Soil Testing Handbook.
14. Soil Engineering Handbook.
15. Foundation Engineering Handbook.
16. Handbook for Engineering Measurements.
17. Handbook on Safety in Construction.
18. Handbook of Building Construction Practices under preparation).
19. Civil Engineering Drawing and Detailing Handbook (in various parts : (a) R.C.C. and prestressed concrete. (b) Steel structures. (c) Irrigation structures. (d) Buildings. (e) Bridges. (f) Public health engineering).
20. Handbook of Summary of Specifications for Building Materials
21. Properties of Building Materials.
22. Handbook of Timber and Timber Products for Civil Engineering Purposes
23. Handbook on Industrial Buildings.
24. Hand book on Electrical Services in Buildings.
25. Plastic Design in Steel-Design aids, explanatory handbook
26. Buildings Bylaws and Municipal Regulations for Buildings.

OPOSAL FOR SETTING UP OF AN INTERNATIONAL CONSULTANCY BUREAU IN /IL ENGINEERING INCLUDING STRUCTURAL, HIGHWAY AND PUBLIC HEALTH GINEERING IN CSIR COMPLEX, MADRAS (78 lakhs, 22.63 lakhs capital expenditure)

To start with, the Consultancy Bureau will function as an adjunct to SERC, Madras with siderable autonomy, and when it grows in stature, it will be constituted as an independent anisation.

Function

To act as the link with other consultancy organisations and liaise with them, to loca consultancy assignments abroad on its own initiative; to get work done through CSIR labs, co sulting firms, universities; to sell computer "software" that is developed indigenously.

The following areas for international consultancy are proposed:

1. Mass-housing projects.
2. Civil, structural, and public health engineering components of industrial complexe
3. Highway systems, including preliminary surveys, alignment, geometrical design ar pavement design and airport runways.
4. Rural and urban water supply and sewage disposal schemes.
5. Drainage and treatment of industrial effluents.
6. Marine and hydraulic structures, including ports and harbours.
7. Bridges in reinforced and prestressed concrete and steel.
8. Transmission line, microwave, and television towers.
9. Office and institutional complexes.
10. Foundations for buildings and machinery.
11. Grain storage structures, including silos. Bins for storage of other commodities.
12. Monumental structures.
13. Miscellaneous structures, such as cooling towers, chimneys, flyovers, and elevat garages.
14. Computer software development for export.
15. Preparation of detailed designs and drawings on contract to foreign firms operating Asia, Africa, and Latin America.
16. Registration with the World Bank (IBRD), the Asian Development Bank, and U. N agencies for consultancy assignments.

NATIONAL COUNCIL FOR RESEARCH IN INTEGRATED RURAL, URBAN AN REGIONAL DEVELOPMENT (OR NATIONAL RESEARCH BOARD FOR HUMAN SETTLEMENTS AND PHYSICAL ENVIRONMENT)

This Council/Board may be set up on a pattern similar to Indian Council for Social Scienc Research/ICAR/ICMR, to tackle the vital problem of human settlements. This will have repre sentatives from the various professions dealing with urban development such as town planner architects, civil engineers, sanitary engineers, transportation specialists, housing specialists, socio logists, economists, administrators, lawyers, political scientists, ecologists, geographers, region scientists, real estate developers, and management specialists, etc.

Objectives:

1. To coordinate research and development in the above areas.
2. To have specialised training programmes.
3. To coordinate integrated teaching programmes, dealing with engineering, planning an management.
4. To sponsor R & D studies and coordinate them.
5. To study and assess the changing concepts on human settlement throughout the worl and to evaluate their relevance to the conditions in India and to suitably modify adept and develop them for the Indian environment.
6. To advise the government regarding policies relating to Urban Affairs, on the bas of systematic studies carried out or sponsored by the Coordinating Council.

number of ministries at the Centre deal with Urban Development, Industrial Townships,
uch as Ministry of Works & Housing, Ministry of Industrial Development, Ministry of
leum & Chemicals, Ministry of Heavy Industries, Ministry of Mines, Metals and Steel, etc.
ldition, for development of land use surveys in the country, it is to work with Geological
y of India (GSI), Survey of India and Ministry of Agriculture. Integration with Metropolitan
Development Authorities, Municipalities, Panchayats and other rural bodies; studies in socio-
mic regions are also needed.

ecause there is no National Research Institute or State Level Research Institute to deal with
ems of Urban Development, Regional Development, etc., relating to human settlements and
trial growth and because Research and Development is carried out in Universities, Institutes
chnology, Management, etc., and by R & D Cells in State and Central Town and Country
ning Organisations, Metropolitan Development Authorities, it is necessary to have a National
arch Council to plan, coordinate and direct research affairs.

STANDING GROUP ON NEW TOWNS

Multidisciplinary efforts required in planning, engg. economics, finance, management, urban
gy, regional science, public health engineering, transportation planning.

"New" Towns are dealt by many ministries and central, state and town development agencies,
try of Works & Housing, Industrial Development, Steel, Mines and Metals, Petroleum and
nicals etc. Existing "New" Towns, Durgapur, Chandigarh, Faridabad, Kalyan. "New"
s proposed such as Hospet, Salem, Twin city of Bombay.

ponsoring R & D studies, from private urban design firms, interdisciplinary group teams,
ıdy:

(i) Physical Layout Vs. Infrastructure Costs vis-a-vis present spatial planning standards.

(ii) Services-Transportation, Housing, Water Supply, Sanitation & PHE, Environmental Engg. & Ecology, and its relationship to Density, Layout (grid iron, radial etc.) and Planning Standards.

(iii) High, Medium and Small Densities-Community Facilities, Quality of Life, Services.

TING UP OF A NATIONAL INSTITUTE FOR RURAL, URBAN AND REGIONAL DEVELOPMENT SYSTEMS

here is no single research institute in the country for carrying out studies/R & D work
rban Development (like CBRI, SERC of CSIR, ICSR, IARI, IVRI of ICAR).

kistics is defined as the Science of Human Settlements, research and teaching, including
alised training. National Institute to initiate, carry out and coordinate studies all over
. Highly multidisciplinary with the following fields :

lanning, Architecture, Design Engg., Structural, Transportation, Construction, Public Health
Environmental. Earth Sciences and Geotechnical Engineering. Economics, Mechanical (Envi-
ental Services), Electrical, Telecommunications, Sociology, Economics and Statistics, Demo-
hy, Geography and Spatial Systems Ecology, Regional Science and Development Systems
ysis, Law Political Science; facilities from JNU, Delhi University, Indian Instt. of Public
inistration, IIT, Delhi School of Planning and Architecture, Instt. of Economic Growth, Ins-
of Social Change, Centre for Study of Developing Societies Computer Centre; may be hous-
JNU initially and later into a unit between JNU & IIT Delhi.

The following schools may be set up to have an interdisciplinary approach :

1. School for Urban Affairs.
    - (a) Center for Urban Infrastructure.
    - (b) Center for Urban Systems Engg.
    - (c) Center for Urban Sociology.
    - (d) Center for Urban Administration and Management. IIPA has a Center for Mu cipal Administration.
    - (e) Center for Urban Economics.
    - (f) Center for Policy Formulation and Decision Making in Urban Affairs.
2. School for Rural Development Systems.
3. School for Integrated Regional Development Studies—Systems Approach; or Natio Institute for Urban Systems Engineering (both "hardware", "software" includi management), postgraduate education, research, specialised training; or Joint Cen for Urban Studies (JNU-IIT-SPA) in Delhi.

SETTING UP OF INSTITUTE OF ENVIRONMENTAL RESEARCH, STUDIES AND TRAINING

At Jadavpur University, Calcutta using existing facilities in Civil and Chemical Engineer Departments.

Functions

1. Organise purposeful research and studies, primarily in the following fields, as related environment, for generating knowledge and techniques, as would be of immediate relevance the country's environmental needs and programmes.

- (i) Human settlements (including environment, built environment, public health engine ing)
- (ii) Human Ecology
- (iii) Rational Management of Natural Resources
- (iv) Management on Environmental Ecology

2. Innovation of new technology or adaptation of existing technology, available from resear and experiences of other countries, for effective utilisation in the country's environmental contr through well organised technical, research and developmental activities.

3. Introducing in the near future, short environmental appreciation courses, for in-service p sonnel, and orientation courses for university students who are likely to become professiona involved in environmental management, and evolving in the short run, a balanced course environmental science and technology, for both under-graduate and post-graduate education.

SECTOR : FAMILY WELFARE AND HEALTH

FAMILY WELFARE & HEALTH

n its approach to the Fifth Five Year Plan the Planning Commission emphasised the need appropriate strategies for better health and nutrition and for a check in population overvth. This is a gigantic problem requiring considerable resources. The Steering Group of Planning Commission on Health, Family Planning and Nutrition has proposed an overall ay (Central and States) of Rs. 2105 crores during the Fifth Plan period in this sector. The k-up of this would be as follows :—

1. Health	Rs. 940 crores
2. Family Planning	Rs. 560 crores
3. Nutrition	Rs. 605 crores

The National Committee on Science & Technology which is charged with the responsibility preparing the overall science and technology plan within the socio-economic objectives laid n by the Planning Commission constituted a number of panels for the different sectors of economy. One of the Panels so constituted related to Family Welfare & Health. This el, unlike the other panels of the NCST, did not set up a large number of planning groups by f for preparation of the plans in the respective sub-sectors except in a few areas, but decided work in close cooperation with current efforts of the Planning Commission, the Ministry of lth & Family Planning and ICMR.

In so far as research and development in family planning is concerned, the NCST panel ided that it would depend upon the work of the Coordination Committee for Research in nan Reproduction and Fertility Control set up by the Ministry of Health and Family Plang. The Coordination Committee prepared a series of reports on the following subjects :—

(a) The present state of knowledge in the field of human fertility control.

(b) Identification of immediate problems including innovative techniques needed for the successful execution of the family planning programme.

(c) Long term strategy and planning of research in human reproduction.

(d) Bio-social research.

(e) Education and training.

These reports were synthesised by the Coordination Committee and the financial outlay isaged by the various groups amounted to Rs. 19.30 crores for bio-medical research and 6.90 crores for bio-social research. The total outlay for bio-social and bio-medical research Rs. 26.20 crores. In view of the financial constraints, it is believed that a sum of at least 13.00 crores would be needed for R&D in this area to provide the requisite support for the ily planning programme itself.

In addition to these outlays envisaged by the Coordination Committee, the NCST also proes an additional outlay of Rs. 1 crore for (i) research into immediate problems and innovative nniques for promoting the current family planning programme and (ii) for education and ning.

The NCST constituted a Task Force on Nutrition in collaboration with the Planning Comsion. The Task Force on Nutrition presented its report which spelt out the various strategies that are necessary to fight mal-nutrition in the country particularly amongst the children and expectant and nursing mothers. The total allocation envisaged for these programmes would be Rs. 2.25 crores.

The NCST also constituted a Working Group of pharmacologists and other scientists connected with drugs to make appropriate recommendations for strengthening the facilities for clinical trials of drugs with a view to facilitate the development of indigenous capability for the manufacture of drugs on a priority basis for the major health problems of the country. The group is yet to finalise its report. However, it is tentatively proposed that an allocation of Rs. 1 crore may be needed during the Fifth Plan for this programme.

The NCST set up a Panel on Communicable Diseases in June, 1973. The Panel met only once so far and has indicated broad area of R and D effort needed in this field.

Detailed project formulation and implementation of the proposals will be a joint effort between the Ministry of Health and Family Planning, ICMR and NCST.

I. FAMILY PLANNING

Any strategy for checking the explosive rate of growth of the population calls for immediate action and better understanding of all facets of human reproduction extending from the bio-medical to the bio-social areas. At the moment, there is an immediate need for focussing attention on problems arising in the field and for innovative techniques. Studies on the epidemiology of abortions, assessment of the acceptance of differing methods of family planning in different areas of the country, evaluation of different surgical techniques of vasectomy, studies of various methods of tubectomy, assessment of mass vasectomy camps as a family planning measure, determination of causes of failures of I.U.C.D. are some of the immediate problems which require research and development.

The area of education and training for family planning requires numerous studies, both operational and educational. The assessment of the effectiveness of rural field practice as taught to under graduates in different medical colleges today, the development of a methodology for increased involvement of medical colleges in community health, the problems related to the training of basic health workers, the effective utilisation of A.N.Ms. as multi-purpose health workers, studies of problems of managerial training to family planning officers are some of the areas which require immediate attention.

The current and projected family planning programmes require intensive research effort in bio-social areas. Physiological factors and their interaction with socio-cultural factors have numerous facets which require investigation, assessment and operational research. The family planning programme has important health aspects especially with regard to the health of mothers and infants, effect of abortion on maternal health, relation between repeated programmes and the health of the mother and child, effect of malnutrition and child health etc. These inter-relations require intensive study.

There is also a need to determine the differential in family planning and contraceptive practices, cost benefit analysis of the various intervention techniques and appropriate methodology for an on going evaluation of the demographic impact of family planning programmes. Refinements in methodology and development of sensitive indices are needed.

Bio-medical research in the family planning programme covers a wide area. Studies on contraceptive steroids, intra-uterine contraceptive devices, clinical evaluation of fertility regulating agents, prostaglandins and fertility control, methods to detect evaluation time studies on hormonal antagonists, control of fertility in the male, problems related to the sperm survival in he female genital tract, the transport of ovum and its implantation, clinical studies to collect base line data and studies on abortion are some of the major areas of bio-medical research for his programme. The bulk of the programmes identified have either an immediate or long term mission-oriented approach.

II. HEALTH

1. *National programmes for the control of communicable diseases.*

There is considerable amount of scientific knowledge available, on the basis of which control programmes against Communicable Diseases have been initiated. However, our knowledge of the epidemiology and various other facets of many communicable diseases, is still nadequate, there is need for more intensive concurrent evaluation of the control programmes; there are some diseases where intensive laboratory research is still needed. Research programmes aimed at solution of problems and difficulties may extend from basic research in the laboratory to a study of managerial, human and even social factors for achieving success. The National Malaria Eradication Programme and the National Smallpox Eradication Programme require both field and laboratory research to strengthen the programmes. There are many facets of the National Filaria Programme and National Leprosy Control Programme where intensive research is necessary to determine the epidemiology of the diseases and to develop the best strategy for attack. The National Tuberculosis programme requires careful evaluation and survey in selected areas and operational research in many fields for control of the disease. A small component of research is also essential for the National Trachoma Control and National V.D. Control Programmes. The Cholera Control Programme is intimately related to environmental sanitation ; there are many areas which are related to the production of effective vaccines against the vibrio requiring detailed immunological studies.

2. *Viral bacterial, fungal and parasitic infections.*

Apart from the so-called major communicable diseases referred to above, there are a number of other infections that continue to be important causes of mortality and morbidity in the country. These diseases should be understood in a wider sense to include all diseases caused by bacteria, fungi, viruses and parasites.

A large part of the morbidity and mortality is due to viruses which pose special problems both for investigation and for control. A very large number of viruses have been discovered throughout the world during the last 20 years and a vast majority of them await detection and investigation in this country. Rabies, poliomyelitis and related viruses and Hepatitis viruses cause extensive morbidity and mortality in this country. Vaccines are available for the first two. These require intensive research to make them more effective. Viruses transmitted by arthropods constitute a very large group. Dengue, Chikungunya and Japanese encephalitis and sandfly fever are responsible for extensive outbreaks of fever in this country. Kyasanur Forest disease poses a serious potential threat to the whole country and needs to be considered as a national problem. More than 40 such viruses have already been identified from this country. Twenty-two of these are new to science and their role in causing human disease is yet to be determined through intensive research efforts.

Influenza and related viruses cause respiratory infection responsible for extensive morbidity throughout the population. Over 1500 such viruses are now known. Little work has been done on these viruses in the country.

Numerous other viruses like those of measles, chickenpox, mumps and some suspected of causing cancer have not yet received much attention. Research in this area is in the form of investment leading to accumulation of knowledge to enable the public health authorities to control the infections caused by viruses in time to come.

Research in vaccines and sera against viruses, effective measures for control of reactions of disease and research on interferon, and antiviral substance are needed.

3. *Bacterial infections.*

Foci of zoonotic plague may be persisting in certain parts of the country as plague bacilli, were demonstrated in rodents from some areas till only recently. There is need for continued surveillance of plague in suspected areas. Tetanus is of great importance because of High mortality and requires a national effort to be mounted against it. The immunisation programme against diptheria, tetanus and whooping cough as a part of the package deal for the health protection of children requires considerable operational research with some facets requiring laboratory research. A number of other bacterial infections like typhoid, dysentery, salmonella and ecoli are rampant in the country. Research in this area is essential so that preventive measures can be taken and more effective vaccines made available. A large number of other bacteria cause considerable morbidity and mortality through infections in individuals and in hospital population. Staphylococcal, streptococcal, meningococcal, brucella, and anerobic infections are some of these.

4. *Fungal infections.*

Fungi are known to cause human disease although they have low communicability. There is need to strengthen research effort in this field to determine the prevalence of these infections in the country as a whole.

5. *Parasitic infections.*

Parasitic infections, especially by helminths and protozos are indeed extremely common. The total load of parasitic infections especially by hookworms, ascariasis and amobiasis is enormous and this is a neglected area both as regards teaching and research. Work on the prevalence and prevention of these infestations, especially in the rural population is of considerable public-health importance.

6. *Water supplies and drainage.*

Supply of clean, potable water and simultaneous supply of adequate drainage is one of the major health tasks. This will prevent a large variety of infections. Operational research on how to obtain clean water and render it free of pathogens through simple innovative techniques would assist in making more rapid progress in this field.

7. *Other areas of bio-Medical research.*

Communicable diseases, nutrition and family planning have been accepted as the areas of prime importance in the Health Sector. But many other problems face us because of the changing age structure, problems posed by rapid industrialisation and urbanisation, hazards of chemicals in industry and agriculture, coronory heart disease, environmental pollution and cancer.

Effective health measures and improvement in socio-economic conditions are changing the disease patterns and chronic degenerative disorders; diseases of the heart and arteries and cancer are likely to assume importance in the years to come. Investigations on these conditions are necessary now to prepare for the future. There is also a strong case to develop programmes for early detection of cancer, especially that of the female genital tract and of the oral cavity so that appropriate therapy can be instituted in time. Behavioural sciences, especially in view of the impact of the habits, beliefs and traditional ways of life on the health of the people cannot e neglected. There are indications of a high rate of mental morbidity in the community and nis problem requires further elucidation. There is the vast problem of the handicapped and nis rehabilitation involves much investigative effort.

II. NUTRITION

Mal-nutrition is a major hazard to the health of the people. Apart from affecting children elow five and mothers especially, it imposes a heavy economic burden on all the people. The vert and reported nutritional deficiencies are only the tip of an iceberg. Investments in preenting malnutrition would yield rich dividends in terms of economic progress and welfare. onsiderable research effort is needed in the field of nutrition. The research programmes identied in this area include: monitoring of nutritional status and evaluation of national nutrition rogrammes, studies on the use of common salt fortified with iron for combating iron deficiency nd its field trials, studies on the use of vitamin A in preventing blindness, investigation of utritive value of high yielding variety of cereals, millets and pulses and green leafy vegetables, tudies on prevention and removal of mycotoxin contamination of various types of foods and tudies in food technology.

V. INFRASTRUCTURAL FACILITIES FOR R & D.

. *Strengthening of facilities for laboratory animals including non-human primates.*

Laboratory animals provide one of the most important basic material for bio-medical reearch. More than 40 species of laboratory animals including mice, rate guinea pigs, rabbits, amsters, dogs, cats and chickens are used in these studies. On an average, seven lakhs of aboratory animals per year are being used in this country. A vast majority of them are for edical and bio-medical research.

The conditions of breeding centres for these laboratory animals and the laboratory animal ouses have so far not received the attention which they deserve. Only too often expensive bioogical and bio-medical investigations fail to achieve their objectives because of the inconsistency f the starting material in the laboratory animals. It is, therefore, imperative that facilities for aboratory animals, their breeding and maintenance under standard conditions are strengthened o provide the necessary and essential infrastructure of bio-medical research in the country.

The use of monkeys for experimental work requires even greater attention. Their imporance lies in the fact that of all experimental animals, non-human primates have close anatomical, hysiological and pathological similarities of their organ systems to those of man. he use of simian cells for preparation of vaccines for human use, the similarity of lood group systems, the use of simians for testing drugs for human therapeutics and the similaity of sexual cycle make these animals indispensable for research in various bio-medical areas ncluding human reproduction and nutrition. It is, therefore, essential to pay special attention o the breeding of monkeys, their maintenance under optimal condition of hygiene and nutrition, stablishment of monkey farms, collection of data on the biology of monkeys and finally to estabsh a Research Centre for the study of non-human primates in this country.

. *Strengthening of facilities for instrument workshops and medical engineering centres.*

Bio-medical research, like any other sector requires the use of sophisticated instruments. here is an urgent need for providing facilities for proper maintenance and repair of such equipent both at the level of the institution and also by setting up regional workshops where repairs nd fabrication can be undertaken quickly. There is also a need for setting up bio-medical ngineering centres where fabrication of equipment needed for diagnosis and treatment of human iseases and for bio-medical research can be undertaken.

3. *Operational research on systems of delivery in health care*

Health care of the people is a very complex area which involves interaction of the various programmes initiated by Government and non-governmental agencies and the reactions of the people, their beliefs, customs, and attitudes which differ in rural and urban areas and in different parts of the country. It is generally recognised that there is an under-utilisation of the existing knowledge as well as of the existing services because of lack of adequate information on this interaction. Public health workers all over the country have been suggesting that vertical programmes should be replaced by horizontal multi-purpose workers to overcome some of these defects. There is an urgent need for operational research for bringing about an integration of different components of the health care delivery system. Considerable amount of research effort is necessary for integrating various vertical programmes and multi-disciplinary research including the use of social and behavioural sciences required for understanding the nature of the problems in the field.

4. *Health manpower development*

Research in medical education is a relevant endeavour to produce the new type of community physician or multipurpose worker involved in the health care of rural population. Radical changes in medical education which is today hospital oriented with emphasis on rare diseases are urgently needed. R & D is necessary to evolve entirely new patterns of community based medical education with emphasis on preventive and promotive health.

The implementation of the programme for integration at the business end of the health care requires pilot studies and operational research. Studies on combination of various types of health services, the area and the population to be covered by a multi-purpose worker, the nature of their training programmes, problems relating to health intelligence and collection of statistics, health education programmes for the people, problems relating to training of doctors in community medicine and finally an assessment of the degree of integration achieved between the medical and public health services during the last 30 years at various levels are some of the problems for research in working towards a more effective delivery system for the people. There is also a need for integration of health programmes with family planning and nutrition programmes.

5. *Pilot studies and operational research in health laboratory services*

Laboratory services provide the corner stone for control and surveillance of communicable and infectious diseases. They also provide the basis on which the quality of medical service can be improved to a very large extent. Laboratory services exist in the country only to a limited extent. There is shortage of personnel and training of technicians is inadequate.

A National Health Laboratory Service should cover all aspects of laboratory activity: clinical, epidemiological, public health control of food and drugs, forensic work, nutrition laboratories and those for preparation of vaccines, sera and other biologicals. Such a National Health Laboratory Service will form an integral part of general health service.

Laboratory services would have to be evolved on the basis of pilot studies and operationa research and evaluation in different parts of the country. The laboratory complex consisting o a net work of such units from the primary health centre, regional and district laboratory, the State Centres and the National Reference Centres would require considerable effort in integrat ing them with the general health services. It is, therefore, imperative that pilot sudies and fiel research in this area in different parts of the country be started in the Fifth Plan so that effectiv action can be taken on the basis of the experience gained to set up the net work.

Information system in biomedical sciences

Proposals for setting up a National Information System covering the whole field of Science & Technology have elsewhere been made. Progress in the biomedical field would be facilitated by the inclusion of biomedical sciences in the proposed system.

V. EMPLOYMENT

If the programmes envisaged are carried out during the Fifth Plan period, it is estimated that these would generate employment for about 2050 Medical and Biomedical Scientists, Engineers, paramedical personnel including medical technicians.

VI. FINANCIAL OUTLAYS

The outlay proposed for R & D for the different areas are as given below:—

Sl. No.	Area	Financial outlay (Rs. crores)
1.	**Family Planning**	14.00
2.	**Health**	
	(i) National Programmes of control and eradication of communicable diseases.	3.00
	(ii) Other infectious and communicable diseases including bacterial, viral, fungal and parasitic infections.	12.00
	(iii) Other areas of biomedical research including metabolic, degenerative and mental health.	2.00
	(iv) Clinical trials of drugs.	1.00
3.	**Nutrition**	3.40
4.	**Infrastructural Facilities**	
	(i) Strengthening of facilities for laboratory animals including non-human primates.	4.60
	(ii) Establishment of regional workshops for biomedical engineering, instrument repair.	2.00
	(iii) Operational research on systems of delivery in health care.	4.00
	(iv) Pilot studies and operational research in Health Laboratory Services.	4.00
	TOTAL	50.00

In the field of Nutrition, the details of the various projects are as given below

S. No.	Title of the project	Financial outlay (Rs. in lakhs)
1.	Monitoring of nutritional status and evaluation of National Nutrition Programmes—National Nutrition Monitoring Bureau.	200.00
2.	Use of common salt fortified with iron for combating iron deficiency: Field trials.	13.00
3.	Studies on prophylaxis against blindness due to vitamin A deficiency, using massive doses of oral vitamin A and vitamin E.	2.00
4.	Nutritive value of high yielding variety of cereals, millets and pulses,	14.50
5.	Coordinated Research Programme on Nutritive value of green leafy vegetables.	6.50
6.	Studies on Methodology of Nutrition Education.	50.00
7.	Researches into effective methods of prevention of post-harvest losses and storage of foodgrains at farm level.	10.00
8.	To evaluate effectiveness of various delivery systems in supplementary feeding programmes.	18.00
9.	Studies on the prevention and removal of mycotoxins in agricultural commodities with special emphasis on aflatoxin contamination of groundnuts.	20.00
10.	Studies in food technology to reduce bulk of foods (or increase calorie density) for use in the preparation of ready-to-eat cereals and pulses.	5.00
		339.00

SECTOR—TRANSPORTATION

TRANSPORTATION

Rail Sub-sector:

Railways have a special role to play in the overall National Science and Technology Plan t only to subserve Railway's own needs but also to give a spurt to the vast net-work of vate and public sector industries which supply railway materials and equipments. In order at the Railways S&T programmes were comprehensive, the rail sub-sector was further divided o our areas for which specialist groups were set up. These specialist planning groups have epared their plan covering the entire innovation chain from education to R&D design gineering, testing, production and utilisation. Development of competence in a variety of lds in an integrated manner has been planned so that dependence on foreign technology could almost entirely eliminated. The principal thrust of the Railway S&T Plan is towards lowering transportation cost, improvement of systems operations and equipment performances in the ctor which will represent a total capital investment of approximately Rs. 6000 crores.

The specific terms of reference of these planning groups were as under :—

(i) *Operation* :Optimisation of performance in providing quick and efficient transport ot ods and passengers at minimum cost, taking into consideration developments in other modes transportation and working out optimum strategies and developing the technologies suited th to railway working and to inter-faces with other modes of transport.

(ii) *Equipments*: Identification and formulation of time-bound programmes for technologi- l developments required in railway equipment for traction, rolling stock, tracks, bridges, signall- g, etc. and continuous improvement of their performance and capacities.

(iii) *Materials* : To forecast and specify requirements of special materials for railways, review application of new materials such as plastics, polymers, etc. on a continuing basis and effect economies through advances in natural sciences.

(iv) *New Areas*: Identification and development of strategies for advancement of technolo- ics in new areas such as cybernetics, rapid transit, modernisation of communications, etc.

These planning groups have identified a number of specific R&D tasks to be taken up to chieve the railway development plan targets within the Fifth Plan, as also the long-term objectives hich would reach fruition in the sixth or seventh plans. They have considered the expected crease in the volume of freight traffic from the present level of about 200 million tonnes to 300 illion tonnes by the fifth plan, which would require substantial improvement in operation fficiency of the Railways. The Science and Technology Plan has, therefore, been derived directly rom and is related to the achievement of the fifth Plan targets. It reflects increased inputs towards evelopment of railway equipment for traction, tracks, signalling, etc. so as to continuously mprove their performance and capacity as well as keep abreast of advancements abroad. The pecific programmes cover: design development, production, utilisation, repair and maintenance f rolling stock, signalling, telecommunication and cybernetic; tracks and bridges; electrification: entre buffer coupler and air-brakes; corrosion and wear; welding and welded construction design; esign development of diesel engines; consultancy and export; etc

The following institutional arrangements have been suggested for implementation of the various programmes:—

(i) *Setting up of an Institute of Production, Design, Development and Service Engineering.*

It is suggested that the present Railway Design and Standards Organisation itself could be expanded to undertake this comprehensively.

(ii) *Setting up of an Institute of Optimisation.*

This would deal with transportation systems including pipelines, ropeways, water-ways, etc. to develop integrated optimal transport. The present Directorate of Planning and the Efficiency Bureau could perhaps form the nucleus of growth of this Institute.

(iii) *Setting up of an Institute of Manufacturing, Repairing and Maintenance Technology.*

This would update manufacturing, repairing and maintenance technology to make better use of the railway assets.

(iv) *Linkages with the IIT's, universities, etc.*

Under this scheme, a certain number of officers who have already completed a few years of service would be sent to universities for doctorate studies based on problems of their Railway experience. The Railways would allocate funds to universities, etc. for this purpose.

(v) *Installation of Test Track.*

The absence of a test track is a bottleneck in completing the large programme of actual testing already developed at the RDSO. The expanded future programmes cannot be carried out using open line capacities as these are extremely expensive and take far more time of costly test trains whose utilisation thus falls as low as 10%.

The tasks identified by the various planning groups involve a financial outlay of about Rs. 48 crores. The details of certain other programmes are also being worked out for which an additional sum of Rs. 12 crores will be required. Thus, the S&T programme would involve a total outlay of Rs. 60 crores during the Fifth Plan. This R&D budget will be financed from the Railway Revenue budget which for the Fifth Plan would be of the order of Rs. 12,000 crores. The R&D budget thus works out to 1/2% of the revenue budget. It may be pointed out that the railway Plan allocation envisages an outlay of Rs. 2,350 crores on the basis of traffic of 300 million tonnes freight traffic. This does not include metropolitan transport for which an additional outlay of Rs. 200 crores has been envisaged. The foreign exchange component of the S&T outlay will be Rs. 5 crores and employment generated for 846 engineering graduates, diploma holders and equivalent.

The projects Identified by the Planning Groups are as given below:

Project Index No.	Title of the Project	Financial outlay (Rs. in lakhs)
1	2	3
	I. TRACTION SYSTEM	
$S_9G_1A_1P_1$	Diesel Engineering & Transmission Dev. Lab.	140.00
2	Replacement of Copper Conductor with Aluminium	12.50
3	OHE testing-cum-recording Car	26.00
4	Traction & High Voltage testing laboratory	58.50
5	Electric Testing Laboratory	160.00
6	Dev. Cell for Gas Turbine	70.00
	TOTAL G_1A_1	467.00

1	2	3
	COACHING STOCK	
$G_1A_2P_1$	Noise control	15.25
2	Dust prevention	25.25
3	Improvement of Rly. seating	10.25
4	Air conditioning	5.00
5	Tilting bodied coaching stock	30.75
6	Aerodynamic projects	32.25
7	Pneumatic suspension	12.25
8	Rubber Suspension	10.50
	TOTAL G_1A_2	141.50
	FREIGHT STOCK	
$S_9G_1A_3P_1$	Prototype Dev. Workshop	38.00
2	Testing for Torsional rigidity of wagons	5.50
3	Centre buffer couplers	6.00
4	Spring & Z Bearing Testing	4.50
5	Package testing Lab.	10.00
	TOTAL G_1A_3	64.00
	SUSPENSION DEVELOPMENT	
$S_9G_1A_4P_1$	Additional oscillograph car	32.00
2	Computation facilities in mobile testing cars	119.00
3	Measuring wheeled development	15.00
4	Vehicle Dynamics Lab.	130.00
	TOTAL G_1A_4	296.00
	BRAKE ENGINEERING	
$S_9G_1A_5P_1$	Brake Design, Air Brake test & Mobile Lab.	67.50
2	Nucleus cell for Adhesion research	8.00
	TOTAL G_1A_5	75.50
	STRESS ANALYSIS & TESTING OF MATERIALS	
$S_9G_1A_6P_1$	Experimental stress analysis	23.50
2	Fatigue Testing	33.00
3	Non-destructive testing of materials	121.00
	TOTAL G_1A_6	177.50
	TRACK & BRIDGES	
$S_9G_1A_7P_1$	Lab-cum-workshop for studies on concrete welding material Technology	432.00
2	Rail Research Laboratory	
3	Track Fastening Research Laboratory	
4	Mobile Track Research Lab.	
5	Sleeper Research Laboratory	480.00
6	Bridge Engineering Research Institute	
	TOTAL G_1A_7	912 00

1	2	3
	SIGNALLING SAFETY & CYBERNETICS	
$S_9G_1A_8P_1$	Prototype developmental workshop	184.00
	MULTI-DISCIPLINARY RESEARCH FACILITIES	
$S_9G_1A_9P_1$	Computer Centre	82.50
2	Test Track	1005.00
3	Simulation techniques	11.50
4	Strengthening of electronics Laboratory	123.00
	TOTAL G_1A_9	1222.00
	TRANSPORTATION	
$S_9G_1A_{10}P_1$	Formulation of Transportation plan	30.00
2	Transportation Research	18.00
3	Human Engineering	22.20
4	Electronic Simulator	7.50
	TOTAL G_1A_{10}	77.70
	RAPID TRANSIT SYSTEM	
$S_9G_1A_{11}P_1$	Transportation	813.50
2	Civil Engineering	
3	Electrical Engineering	
4	Rolling Stock	
5	Signalling	
	ENVIRONMENTAL POLLUTION	
$S_9G_1A_{12}P_1$	Task force to be set up for environmental pollution	17.00
$S_9G_1A_{13}P_1$	MANAGEMENT DEVELOPMENT	30.00
	INFORMATION DISSEMINATION	
$S_9G_1A_{14}P_1$	Central Information Centre Library	30.00
2	Equipment	10.00
3	Books, Periodicals	15.00
4	Staff	45.00
5	Zonal Libraries	90.00
6	Books, Periodicals for Zonal Libraries	45.00
7	Deputation abroad	10.00
8	Permanent Representative in UIC, CRE, IFCA, ECAFE, DOT, etc.	30.00
	TOTAL G_1A_{14}	275.00
	MATERIAL SCIENCES DIRECTORATE/DIVISION	
$S_9G_1A_{15}P_1$	Estimate for covered space	23.69
2	Infrastructure	51.00
3	Research Foundry	15.84
4	Recurring Expenditure on officers, Staff & raw material	1.82
	TOTAL G_1A_{15}	92.35
$S_9G_1A_{16}P_1$	Miscellaneous	1167.00
	GRAND TOTAL	6011.55
	or say	6000.00

2. ROAD AND WATER

The road and water sub-sector has been divided into the following 5 areas and specialist roups have examined the R & D tasks in each with regard to the need for optimisation of erformance of mass transportation system :—

(a) Roads and Road Terminal Facilities.
(b) Inland Water Transport.
(c) Shipping and Ship Building.
(d) Road Transport and Vehicles.
(e) Special Modes of Transportation.

n drafting the Science and Technology programmes for inclusion in the Fifth Plan, the goals nd objectives set forth are summarised in the following paragraphs.

a) *Road and Road Terminal Facilities* :

Roads play a vital role in the development of economy of the country. In step with the planned development taking place in the country, specially in agriculture and industrial sectors, the traffic on highways has increased tremendously in the course of just 10-20 years. The rise in traffic has not been limited to the number of vehicles alone, but has been accompanied by a substantial increase in gross laden weights of vehicles. The share of road transport, in the total goods traffic carried by rail and road together, has risen from about 11 per cent in 1950-51 to about 25 per cent in 1968-69, and passenger transport from about 26 per cent in 1950-51 to about 48 per cent in 1968-69. On the export front, road transport carried roughly 62 per cent of the country's total export shipments in 1969-70 valued at about Rs. 1,400 crores.

The total road length in India in 1970-71 under various administrations was about 1.3 million kms. of which only about 0.4 million kms. was surfaced. The road development programmes in the Fifth Plan include :

(i) Consolidation of the existing road net-work through completion of missing links and improvements to geometrics, pavement and riding quality ;
(ii) Widening of heavily trafficked sections to 4 lanes for providing fast and safe movement of long-distance traffic ;
(iii) Expansion of road network through construction of new roads ;
(iv) Construction of roads for rural communication.

With funds for road development being limited, it may not be possible to meet the demands of road traffic in full. Unsurfaced roads are unsuitable for present day fast moving traffic and lead to higher vehicle operation costs, delays and accidents. On the surfaced roads also, unless quality standards are raised through continuous research and development efforts, the same defects prevail though to a lesser degree. The Keskar Committee in its report presented in 1969 has estimated that because of deficiencies of road network, the excess in operational costs of nation's motor fleet in 1970-71 would be of the order of Rs. 180 crores. This would involve an irrationally high consumption of fuel by as much as 26 per cent leading to needlessly larger imports of oil.

Therefore, in recent years, consciousness regarding improving overall road standards in the country has been continuously growing. Research and development can contribute considerably towards bridging the gap through application of improved planning, design, construction and maintenance techniques including use of local materials. At the moment, the three main research agencies in the country, namely, the national laboratories (such as CRRI), the laboratories under the State PWDs and the universities are working without any coordination. Also the efforts of these agencies are grossly inadequate due to very limited funds. State PWD do bulk of road construction and maintenance, but the basic laboratory facilities for the inductio of science and technology are by and large non-existent. Non-availability of adequate number of trained personnel having the right type of developmental aptitude is another factor inhibitin the process of research and development. Organised training facilities for engineers and middle level technicians are almost absent. For effective and meaningful research and developmen in the road sector, a start has therefore to be made from a rather low level. The first ste will be creation of a proper infra-structure for research, overseeing and establishment of additional facilities for research, and qualitative improvement to the organisational structure of th executing agencies that are to implement the research findings.

The total cost of R & D tasks identified comes to about Rs. 18 crores, out of which hal will be in the state sector. As some schemes would spill over to the Sixth Plan, therefore a provision of about Rs. 15 crores would be required in the Fifth Plan, (Central sector Rs. 7 crores and State sector Rs. 8 crores.) The foreign exchange component is expected to be Rs. 1 crore. The overall outlay for road development under the central and centrally-sponsored schemes in the Fifth Plan is of the order of Rs. 600-700 crores.

The road transport is going to be a most important infrastructure in developmental activities envisaged in the Fifth Plan. The Group on Road Transport and Vehicles has, therefore, recommended that the research and development activities may be stepped up in problem areas faced by different types of vehicles. The R & D efforts will also be directed towards the development of vehicles and ancillaries required for road transport, both passenger and goods. The following are proposed to be taken up :—

(i) Test Rigs

(ii) Machinery

(iii) Instrumentation

(iv) Trial tracks

(v) Training abroad.

The above projects for which details are being worked out will cost Rs. 31 crores, of which about Rs. 3 crores may be in foreign exchange.

(b) *Inland Water Transport* :

The planning group on Inland Water Transport has made several recommendations for integrated development of the inland water transport system for which there is already sufficient scope. The recommendations include engineering studies of optimum cross sections of navigable channels, vertical clearance of bridges covering navigable waterways,embankment/lining of banks suitable for vulnerable reaches of navigable waterways ; hydrographic surveys, river training and conservancy; standardisation of navigational aids; mechanisation of country boats and possibility of indigenous production of in-board and out-board engines, schottel navigation and other equipment; standardisation of ferry-craft and tugs; etc. A broad traffic study with a view to assessing the nature and volume of traffic likely to avail of inland water transport in different parts of the country is proposed to be undertaken.

The total financial outlay for identified projects amounts to about Rs. 80 lakhs, including a foreign exchange component of Rs. 8 lakhs.

c) *Shipping (including Coastal Shipping) and Ship Building*:

The overall Fifth Plan target for shipping is around 10 million GRT. The contribution of ndian shipyards to the growth of this tonnage has been very meagre, namely about 0.08 million GRT at all the three shipyards. Even when the new shipyard of Cochin comes into production. he contribution of Indian shipyards may increase to around 0.18 million GRT. Thus, indigenous production of ships would cover only around 10 per cent to 12 per cent of the estimaed tonnage per year required during the Fifth Plan. In order to reduce dependence on foreign shipyards, it is essential to develop indigenous ship building industry. A very serious difficulty n shipping and ship-building industry has been the lack of indigenous R&D effort in ship design, naval architecture and ship building techniques. The programmes proposed by the planning group on shipping would help to increase the extent of indigenous ship-building. A sum of Rs. 5.06 crores has been suggested as the R & D input in the shipping and ship building plan including a foreign exchange component of Rs. 0.42 crores. An outlay of Rs. 370 crores is envisaged by Working Group set up by the Ministry of Shipping and Transport during the Fifth Plan.

(d) *Special Modes of Transportation*:

The group on Special Modes of Transportation has considered transportation of materials over long distances. Transportation within an industrial complex or between nearby industrial units has not been considered. The main area of coverage is for bulk transportation.

The special modes of transport considered are (i) Aerial Ropeway, (ii) Conveyor System, and (iii) Slurry pipe lines. They have an advantage over conventional modes of transportation (roads, railways and inland waterways) in that extensive acquisition of land with heavy crossings built at considerable cost is avoided. They give advantages with regard to power inputs, construction costs, aesthetic conditions, etc. For example, compared to road and railway transport, special modes of transportation are expected to cost 30 to 50 per cent less per tonne kilometre. Nearly 88 per cent equivalent road or rail length can be saved by installing ropeway or pipeline in rugged terrains. About 80 per cent saving in heavy investment may be feasible if ropeways or pipelines are laid specially over rivers which are of shifting nature. They also overcome obstacles, such as rough terrain, intervention of living area and other complexes where a free way is not available, marshy land, flowing rivers, canals, etc, which are the main restrictions for long distance bulk transportation by conventional means. The following paragraphs indicate the status of technology, feasibility and techno-economic merits, organisational arrangements, plan of work, manpower requirements and outlays required to develop specialised modes of transporttation.

(i) *Aerial Ropeway*:

The ropeway is suited where heavy grades are to be negotiated specially in hilly areas. It is also more economical in marshy areas for crossing rivers, straits, lakes and canals. Ropeways are presently adopted for service in remote construction projects, interpoint transportation in marshy land reaches, over wide and fluctuating rivers, for waste disposal at power plants and in passenger-*cum*-material transport routes over dense and steep hill reaches. There are at present about 25 ropeways in the country which are used for long-distance transport of stowage sand, coal etc. The lengths vary upto 54km. and capacities 120/150 tons to 400 tons per hour with speeds averaging 3.5 metres per second for bicable ropeways. Diameter of ropes is available upto 26 mm/40 mm range, though for the track rope diameters upto 62 mm have been used. Whilst the power requirement varies from site to site, normal length installations requires between 1 to 1.2 installed HP per ton of material moved per hour. At present 6 companies are desigining and producing aerial ropeway installations in the country. Testing and R & D facilities exist at the Central Mining Research Station, Dhanbad. Manufacturing potential for the smooth and locked coil ropes suitable for aerial ropeways also exist and developing further ranges continues with 9 SWR manufacturing firms. Higher technological training and research facilities are under development at the Indian Institute of Technology at Kharagpur and Madras.

Aerial ropeways have been developed for long hauls and at present are restricted in capacity mainly due to the restrictions in available steel wire ropes. With the development of smooth coil wire ropes and locked coil ropes of 66 mm diameter, the major problem remaining to be solved will be the ratio of R & D inputs to the resultant increase in off-take of manufactured products. A certain amount of rationalisation of unit ranges and standardisation of components of the existing systems could improve the off-take quantities by reducing job to job tailored inputs. It is proposed to consider 20km length with 500 tons per hour as one range and 10 to 15 km. length with 150/200 tons per hour as another range. The know-how is at present imported as consultancy in respect of long-distance units. Indigenous capacity, though developed, is handicapped in implementation due to lack of R & D inputs.

(ii) *Conveyor System*

With considerable length of belt conveyors installed in the country, several installations can be classified as long-distance systems. The longest single flight conveyor is 2.5 km. located at Bailadilla. Throughputs of 2 to 10 million tons per annum are being handled. Belt speeds vary from 2 metres per second to 3.5 metres per second. More than 7 undertakings manufacture conveyors and indigenous capacity exists for production of belts, bearings, idlers, drive motors, fluid couplings and other associated components. There is difficulty in procuring high tension belts, with steel cord construction and steel cable construction, which are imported at present. Design and consultancy facilities existing in India can meet demands comfortably. Testing and R&D facilities exist in IITs, CMRI & CMERI, Durgapur and CMRS, Dhanbad. Higher technological training and reaserch facilities are under development at the IIT, Madras. Synthetic fabric duck belt production is in quite an advanced stage in the country. Enough expertise is already available for individual conveyor lengths upto 3 kilometres and R & D will be required for developing higher tension belts for increasing unit conveyor lengths. Fluid coupling for drives, regenerative systems for downhill units, friction linings for transmission of power, friction reduction systems for idlers and return belt for carrying loads frcm unloading point back to loading point require developmental efforts.

(iii) *Slurry Pipelines.*

Transportation by pipeline is ideally suited for fine ore, coal, limestone, etc. which can be easily fluidised by water. The horse power requirement is lowest for sulrry transport per t.p.h when compared with that of conveyor and the ropeway systems. Dispersal of fluid medium at point of discharge without environmental pollution is a major problem in the system. In India, slurry transport is mainly in vogue as an internal transport system within a complex such as dredging of sand in land reclamation and mine stowage, wood chip/pulp transporation in paper industry, coal transport for power plants, etc. Long distance pipeline transport in view of its cost per ten km advantage is being planned for consideration in 4 projects apart from the petroleum slurry line. With increasing nuclear power stations and urban concentrations, waste disposal will also involve long distance pipelines. Manfacturing capacity for pipelines, heavy duty valves, hydraulic installations, control systems, etc. exist, though coordinated facilities as applicable to pipeline transport system are still to be developed. Basic R&D inputs on development of component systems already exist and only continuing inputs on adapting the systems for long distance conveying with particular reference to controls, wear and replacements, prevention of system failures, settlement of slurry material including re-slurrying processes, etc. are to be planned.

gineering and consultancy input is at present in early stages of development in the country. search facilities are being created in higher technological institutions and prototype or pilot ant/test facilities are required to be introduced afresh.

The projects for development of the special modes of transport will require science and chnology inputs towards the following :—

(1) Development of the design facilities and carrying out feasibility studies.

(2) Carrying out fundamental studies, performance studies and applied research.

(3) Standardisation of the components and capacities and working out unified code for the country.

(4) Development of communication, control and measuring equipments.

(5) Creation of centralised facility for manpower training.

(6) Development of component equipment which are of specialised nature such as grips, large diameter rope, pipes, special pumps, breaking units, high tension conveyor belts, etc.

The objective is to develop indigenous technology for manufacturing low off-take imported uipment, test pilot plants suitable for long distance haulage and develop metallurgy and manucture of strategic components. In the case of pipeline transportation, basic technology and lied research are also required in addition to pilot plant testing facilities and their allied R&D puts.

ajor recommendations of the planning group on Special Modes of Transportation are :—

(1) A central facility for design, research and feasibility studies for all special modes of ansportation should be developed with complete test bed and training facilities. This set-up ill provide training facilities for specialised inter-disciplinary skill technicians, higher technolocal applied research engineers, in addition to pilot plant or prototype test facilities linked with a entral consultancy engineering institutions like NIDC, New Delhi.

(2) Fundamental performance studies, test facilities, applied research and production devepment with industry sponsored programmes at Central Mining Research Station, Dhanbad and entral Mechanical Engineering Research Institute, Durgapur.

(3) Standardisation of components, formulation of unified codes of practice to be underken by the Indian Standards Institute.

(4) Centralised manpower training facilities at graduate level with IIT Kharagpur (for peways), IIT, Madras (for conveyors) and IIT, Bombay (for pipelines) and Regional Engineerg Colleges.

(5) Development of communication and control equipment, measuring and indicating instruents, safety devices, etc. to be undertaken at the Central Institute for Instrumentation Technoloy, Central Electronic Research Institute, Bharat Electronics, Bharat Heavy Plates and Vessels, harat Dynamics, Bharat Heavy Electricals and other allied Institutions with proper industrial onsorship and centralised coordination.

(6) A group of advisers from research institutions, IITs, industries and connected Government Departments, should be constituted with co-opted members from public sector manufacuring units, consulting engineers, etc. to identify specific sectors for development with the ndividual units.

(7) It is estimated that 615 additional man years will be required to implement the projects.

The detailed assessment of the existing personnel, optimum requirement for viable functioning of the proposals and the pattern of requirement during the coming decade will be done by a planning group.

The R&D inputs will require a total financial outlay of Rs. 162.40 lakhs as per details given below:—

Capital—(a)	Land and building, plant and machinery and others.	Rs. 31.00 lakhs
(b)	Foreign exchange included in (a) above	Rs. 4.75 ,,
Revenue—(a)	Salaries/consumable materials, etc.	Rs. 131.40 ,,
(b)	Foreign exchange included in (a) above	Rs. 1.02 ,,
	Total outlay	Rs. 162.40 lakhs

The estimate is based on a broad analysis of expenditure in projects of similar nature at IITs and CSIR laboratories.

The R & D expenditure of Rs. 162.40 lakhs will generate a production of Rs. 2,215 lakhs resulting in import substitution of the order of Rs. 49 lakhs and is expected to generate employment potential for 201 people during research and development and 2,175 during commercial implementation for higher technology qualified engineers.

The financial outlays proposed by the various groups are as under

Project Index No.	Title of the project	Financial Outlay (Rs. in Lakhs)
1	2	3
	Roads & Terminal facility	
$S_1G_2A_1P_1$	Establishment of R&D Cells at the centre and in the states	60.0
2.	Setting up of Highway Research Board.	7.5
3.	Setting up of training units in the states.	60.0
4.	Establishment of Staff College for highway engineers.	37.5
5.	Setting up of Highway Design and Consultancy Cell	25.0
6.	Setting up of a Centre for Transportation studies.	40.0
7.	Augmentation of the existing laboratory facilities in the states.	60.0
8.	Augmentation of facilities for hydraulic research pertaining to highway bridges.	30.0
9.	Survey and evaluation of locally available materials.	200.0
10.	Planning studies.	500.0
11.	Design studies.	200.0
12.	Materials and construction.	150.0
13.	Traffic operations	75.0
14.	Bridges and other highway structure.	100.0
15.	Test tracks	200.0
16.	Road making machinery:	
	(a) Indigenous design for soil stabilizer (b) evaluation of performances and improvements to designs of indigenous machinery.	75.0
17.	Terminal facilities.	20.0
	Total :G_2 A_1	1840.0
	V Plan component	1500.00

1	2	3
	INLAND WATER TRANSPORT	
$G_2A_2P_1$	**Engineering Studies**	
	(a) Study of the optimum cross sections of navigable channels with reference to types of craft to be employed	10.00
	(b) vertical clearance of bridges covering navigable waterways	
	(c) types of embankment/lining of banks suitable for vulnerable reaches of navigable waterways.	
2	Hydrographic surveys, River Training and conservancy	15.00
3	Standardisation of navigational aids for inland waterways	5.00
4	(a) Mechanisation of countryboats—feasibility and utility	25.00
	(b) The possibility of indigenous production of in-board and out-board engines, schottel navigation and other equipment specially useful for the inland waterways.	
5	Traffic study with a view to make an assessment of the nature and volume of traffic likely to avail of inland water transport in the different parts of the country	10.00
6	(a) Standardisation of ferry craft & tugs	8.0
	(b) Development of craft for fast transportation of passengers.	
7	Adaption of inland water draft for meeting the requirements of container traffic	1.00
8	Terminal facilities needed at inland ports	5.00
9	Rationalisation of the manning scale of inland craft, dumb and powered keeping in view the distinct requirements of the various inland waterways and ports	1.00
	TOTAL G_2A_2	80.00
	SHIPPING, SHIP BUILDING AND COASTAL SHIPPING	
$G_2A_3P_1$	Establishment of a central design organisation	50.00
2	Strengthening of facilities for ship models & propellers	
	(i) Installing of a longer and wider tank (dim. 300 × 15 × 7.5 metres) with a trolley speed fitted with dynamometer and data logging equipment	270.00
	(ii) Manoeuvring basin (dim . 86 × 80 × 5.5 metres) fitted with wave generator and instruments for measurement of ship behaviour data	36.00
	(iii) Cavitation tunnel (dim. 700 × 700 metres)	10.00
3	Augmentation of equipment, material and manpower for structural testing of ship members like frames, girders and fabricated units	25.00
4	Development of software for computers available in Govt. institutions, national laboratories and universities suitable for ship design and ship production techniques	20.00
5	Research in use of alternative material for large scale production of small ships	15.00
6	Setting up of a cell to study route economics and optimisation techniques	5.00
7	Establishment of an Indian Classification Society	25.00
8	Expansion of facilities for teaching naval architecture	50.00
	TOTAL G_2A_3	506.00
	ROAD TRANSPORT AND VEHICLES	
$G_2A_4P_1$	Road Transport and Vehicles	3100

1	2	3
$S_9G_2A_4$	**SPECIAL MODES OF TRANSPORTATION**	
	AERIAL ROPEWAYS :	
$S_9G_2A_5P_1$	Development of specifications, uniform code for construction and central legislation for a national level ropeway Act	*
2	Development of design and feasibility study facilities centrally with N.I.D.C. etc. .	*
3	Fundamental studies, testing and performance studies of ropes, component parts and applied research on specific problems	*
4	Study of metallurgical problems	*
5	Development of instrumentation and communication equipment	*
6	*Manpower Training:*—Short term reorientation/refresher courses of 3 months duration at Post Graduate Level	*
	BELT CONVEYORS :	
7	Fundamental & System Research, component development etc.	*
8	Efficiency and know how studies	*
9	Development of application engineering	*
10	Industry, Research & Allied studies concurrent seminars	*
11	Standardisation of components and rationalisation of ranges	*
12	Data bank facilities to be created by 1974	*
13	Post Graduate training programmes for industry sponsored graduates . .	*
14	Intra Technology coordination seminars	*
15	Specialised manpower training in allied technologies of instrumentation, control gear, metallurgy, rubber technology, structural designs, electrical powering etc.	
	SLURRY PIPELINE TRANSPORTATION :	
16	Fundamental & system reasearch facilities	
17	Applied research training for pump design, control gear, communication and safety equipment	
18	Test bed, prototype plant construction, operational and wear studies facilities to be created at Central Institute	
19	Intra Technology research facility on impellor metallurgy, wear lining for pipes, back pressure release, etc. at related institutes	
20	Specialised manpower training	
21	Data bank central coordination agency	
22	Operation and maintenance technicians training programme	
	TOTAL G_2A_5	Rs.

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*Break up of financial outlays for individual projects not indicated.

CTOR—RESEARCH SUPPORT, EXTENSION AND EDUCATION

RESEARCH SUPPORT, EXTENSION AND EDUCATION

The National Committee on Science and Technology (NCST) constituted a panel on Education and Scientific Research to examine the various important educational programmes and research efforts in educational institutions and recommend appropriate measures to support the Science and Technology Plan in this sectro. This pamel set up a group which included eminent scientists and educationists from universities, IIT's and the Planning Commission. Representatives from the Ministry of Education and Social Welfare and University Grants Commission also participated in the deliberations of the group.

2. Apart from the series of meetings the group also had the benefit of the reports of the various Task Forces set up by the Planning Commission and also of the Central Advisory Board of Education. The draft plan of the NCST group was discussed in four NCST regional seminars. In drafting the Plan programmes in the sector on Education and Scientific Research, the NCST Group had in view the objectives in educational planning which included *inter alia* bringing about structural changes in existing programmes and institutions so as to make education very useful and purposeful, providing high quality science education to a larger body of students particularly in the rural areas, including facilities for training and research in educational institutions, providing skilled manpower for the various sectors of industry and finding mismatch between training and employment. The recommendations cover a broad spectrum of scientific activities but do not, however, embrace programmes in general education, agricultural and medical education. The group has identified various programmes for being carried out by the Department of Science and Technology, Ministry of Education and Social Welfare, University Grants Commission, NCSE and NCERT. These programmes along with the outlay indicated are shown elsewhere. The outlay for implementing the programmes falling under the Department of Science and Technology works out to Rs. 45 crores and that under the Ministry of Education and Social Welfare (including UGC) comes to Rs. 333 crores. The project-wise outlay for the Department of Science and Technology and the Ministry of Education and Social Welfare are indicated in Annexures I & II respectively. Two programmes such as production of laboratory equipment and setting up of the Regional S & T libraries, documentation centres etc. have not been shown either under the Department of Science and Technology or the Ministry of Education and Social Welfare. The implementing Ministry/Department has to be identified for these programmes. A brief summary of the recommendations is given in the following paragraphs :—

1. *Science education at various levels*

Science education should be compulsory at school level. Work experience and vocational training should be provided for at least 20 per cent of the students. The standard and quality of science education should be improved by recruiting qualified teaching staff. providing better laboratories/workshops etc.

A few job-oriented courses in sciences, management shop-practice, computer programming, medical technology, fisheries, instrumentation etc. should be introduced in general B.Sc. or B.Sc. (Hons.) for at least 30 per cent of the students.

Summer schools, winter schools, science camps etc. should be utilised to give advanced material to motivated and gifted students.

Research opportunity for teachers in junior/affiliated colleges may be provided through special grants. Motivated students should be associated with research, equipment fabrication and similar projects wherever possible.

II. *Community science centres (Museums)*

Community science centres should be set up to popularise science by setting up museums, organising exhibitions and science fairs. Mobile science vans must be provided to some of the centres to reach neighbouring village schools as well as for extension work. Such centres shall work in close contact or in collaboration with schools and universities/colleges in the region and their programmes will be coordinated by a Central Agency under the Department of Science and Technology. Qualified scientists and engineers should man these centres. It is suggested that two major community science centres (Museums) in two of the large cities and about six to ten medium sized museums be established by the DST. The Ministry of Education will establish some museums through educational institutions.

III. *Audio visual aids*

Tape recorders, TV discs and curriculum films have to be introduced to support and in some instances replace normal class-room teaching. Movie projectors, small television units should be provided to some selected schools and colleges. At least 100 to 150 science curriculum movies should be commissioned to be made in the Fifth Plan. These movies or TV programmes should not be prepared by one or two agencies but thrown open to the teaching community ; individual groups can take up such projects on a contract basis.

IV. *Technical education and technical manpower*

The main thrust in technical education should be in consolidation and upgrading of standards. Standards and quality can be improved by providing the right kind of training programmes whereby students participate in research, design and development work. The areas of major thrust and requirements of technical manpower have to be worked out after the total S & T Plan is ready.

Sandwich courses should be initiated to create opportunities for properly guided apprenticeship wherever possible. Management courses should form part of the curriculum of undergraduate engineering science/humanities education. Special educational programmes should be initiated to provide the right kind of manpower to carry out the Science and Technology Plan. Appropriate infrastructure and facilities for R & D should be created in technical institutions.

V. *Facilities for research and training*

A few exhaustive Science and Technology libraries and documentation centres should be set up in educational institutions in various regions of the country.

Similarly analytical, testing and instrumentation centres should be provided to support R & D activities in educational and industrial organisations. Regional instrumentation centres should maintain and repair equipment in that region and will undertake design and fabrication of instruments and training of technicians.

University Science departments, science colleges and some of the schools should be equipped with workshop facilities for teaching and research purposes and also for fabrication of prototype equipment.

Small computers and desk calculators should be provided to at least some of the colleges and Universities for instruction and research.

VI. *Support for research in educational institutions*

A central autonomous body known as Science and Engineering Research Council should be set up under the Department of Science and Technology to support and foster basic scientific and engineering research in universities and other institutions for which there is very poor support at present. The Council will give importance to emerging interdisciplinary areas where there is much promise and need for increased effort. The SERC will work through expert committees to evaluate proposals from individuals and institutions for support of research, newer facilities and such other programmes that would encourage scientific and engineering research of high calibre.

VII. *Astronomy and Astrophysics*

Apart from the programmes indicated in the preceding paragraphs, a number of programmes in the field of Astronomy and Astrophysics have been identified. These include studies in the determination of fundamental star position, observation of solar corona, chromosphere, photosphere etc ; research in infra-red astronomy, radio astronomy and high energy astronomy for the survey of planets, stars, interstellar matters, nucleii of galaxies and quasars. Programmes for solar stellar studies, milky way and galaxies have also been identified. Schemes, like indigenous development and fabrication of 2-meter all metal infra-red telescope and 5-meter optical telescope have also been suggested. Programmes of laboratory Astrophysics have been identified to be implemented by the universities. The total financial outlay for these programmes is estimated to be Rs. 4.50 crores.

R & D Schemes identified in Astronomy and Astrophysics are given below:—

S.No.	Scheme	Outlay (Rs. Crores)
1	2	3
$S_2G_6A_3P_1$. 1	Study of the Milky way and Galaxies. Improvement of accessories to 104-cm telescope. Completion of 2.3 meter telescope.	2.00
2.	Stellar studies: Accessories for existing telescopes. Starting of 2 meter telescope fabrication.	0.50
3.	Planetary and Stellar Studies equipment for improving the 48 inch telescope	0.40
4.	Short term requirements	
	(i) solar patrol unit	0.10
	(ii) solar magnetograph	0.50
5.	Infrared Astronomy Programme	0.40
6.	Infrared interferometer	0.10
7.	Laboratory Astrophysics	0.50
8.	2-meter all metal infrared telescope	
	TOTAL	4.50

The details of programmes identified by the Group are as given below:—

Project Index No.	Details of projects	Financial Outlay
1	2	3
		(Rs. in crores)
	Selected New Programmes (Central-Sector)	
$S_{19}G_1P_1$.	(a) Work experience and vocational training at school	10.00
	(b) Improvement of science education at school level (recruitment of teachers, better laboratories, etc)	12.00
2.	Centrally administered community schools in the rural parts of the country	70.00
3.	(a) Work experience and job-oriented courses at college level	15.00
	(b) Improvement of science education in college (better laboratories, libraries etc.)	12.00
4.	Educational experiments and new programmes in science education (including talent students programmes), Summer/Winter Schools, preparation of educational materials, laboratory equipment, book translations, Science Camps, exhibitions, teachers training creativity centres, etc.	25.00
5.	Research projects at school level	4.00
6.	Research projects at colleges	10.00
7.	Community Science Centres/Science Education Centres including museums	15.00
8.	Audio-Visual aids (Tape recorders, TV discs, films, etc.)	30.00
9.	Technical Education (Central Sector special programmes, laboratory development, skilled manpower training, research, design and development, management courses/programmes at Central institutions)	120.00
10.	Regional S & T libraries, documentation centres (to be located in educational institutions)	8.00
11.	Regional centres for instrumentation, testing and analytical services	5.00
12.	Production of laboratory equipment	10.00
13.	Workshop facilities in science colleges/departments	5.00
14.	Computers and calculators for colleges/Schools	15.00
15.	Support of basic scientific and engineering Research in Educational and similar institutions	25.00
16.	Reorientation programmes for unemployed Scientists/Engineers	5.00
	Total	396.00

N.B. : 1. The foreign exchange component for the programmes shown at S.No. 10 and 12 is estimated at Rs. 2.00 crores.

2. This does not include projects on Astronomy and Astrophysics.

ANNEXURE—I

Statement showing programmes for funding by the Department of Science and Technology

S.No.	Title of the project	Financial Outlay (Rs. Crores)
1	2	3
1.	Support for basic and engineering research	25.00
2.	Regional Centres for instrumentation, testing and analytical services.	5.00
3.	Science Centres and Museums	15.00
	TOTAL	45.00

.B. The foreign exchange component is estimated at Rs. 4.00 crores.

ANNEXURE—II

Statement showing programmes for being funded by the Ministry of Education and Social Welfare including University Grants Commission

S. No.	Programme	Financial Outlay (Rs. in crores)
1	2	3
1. (a)	Work experience and vocational training at school.	10.00
(b)	Improvement of science education at school level (recruitment of teachers, better laboratories etc.)	12.00
2.	Centrally administered community schools in the rural parts of the country	70.00
3. (a)	Work experience and job-oriented courses at college level.	15.00
(b)	Improvement of science education in college (better laboratories, libraries etc.)	12.00
4.	Educational experiments and new programmes in science education (including talent students programmes) summer/winter schools preparation of educational materials, laboratory equipment, book translations, science camps, exhibitions, teacher training creativity centres, etc.	
(a)	School level	10 00
(b)	College/University level	15.00
5.	Research projects at school level	4.00
6.	Research projects at colleges (students & teachers)	10.00
7.	Audio-Visual aids (Tape recorders, TV discs, films etc.)	30.00
8.	Technical Education (Central sector) special programmes, laboratory development, skilled manpower training, research/design and development, management courses/programmes at central institutions.	120.00
9.	Workshop facilities in science colleges/departments	5.00
10.	Computers and calculators for colleges/schools	15.00
11.	Reorientation programmes for unemployed Scientists/Engineers	5.00
	TOTAL	333.00 crores

SECTOR—INFORMATION

ific and technical information plays in social and economic ic and technical information is beginning to be regarded as emendous growth in the output of scientific information and se information, have brought about the need for effective ed to be assured that all available scientific and technical cientists, engineers, industrialists, policy makers and all others Scientific information services, capable of drawing on world information, will serve a country as the prime coupling l creators of information. If developed properly, it would consciousness among potential information users. Improved ed information is capable of reducing a country's need to ning research and development. It can aid in the transfer

e Information Policy

rnments have a major responsibility for providing information onal information system, governments shall have to formulate which all organisations participating in these activities can facilities are being built up at various levels by major science on the part of the government to work towards a general plan, ormation agencies, indicating the allocation of responsibilities cy is a major component of policy for science and technology. n integral part of overall government policy, linked to social n policy must seek to assure that the world's specialised and nd properly used in guiding social evolution".

information policy is to provide research workers, scientists, gers and more generally all who have some part to play in information they need and this as economically as possible". uild a national information network on the existing infrastrucivities, articulating the various services, developing their strong public initiative and filling in existing gaps. The government responsibility and the means it intends to employ such as coordinating machinery, financial arrangements, etc.

Science Information Policy for developing a national information following :

for building up strong collections in

(3) development of facilities for providing information services to industry ;

(4) establishment of a data bank for scientific and techno-economic information ;

(5) organisation of a national lending library service on the lines of the Nation Lending Library at Boston Spa in the United Kingdom ;

(6) establishment and development of subject-oriented national information grids ;

(7) establishment of a national referral centre to direct the users to existing info mation sources ;

(8) preparation of national union catalogues of holdings of libraries ;

(9) establishment of regional dormitories for storing older material weeded out b service libraries;

(10) promoting the use of microfilms and microfiches of documents ;

(11) creation of information consciousness among users ;

(12) undertaking periodical surveys for assessing information needs and uses in th country,

(13) collaboration with national and international organisations engaged in informatio service ;

(14) building up translation facilities in various languages ;

(15) building up adequate computer facilities for information handling ;

(16) building up adequate reprographic facilities in information centres ;

(17) building up of expertise and provide for training in information field for a adequate number of persons in documentation, information science, communica tion, computer science, reprography and translation ;

(18) ensuring that the service conditions of the information personnel are on par wit those of scientific personnel ;

(19) supporting projects in documentation, information science, communication, compute science, reprography and translation ;

(20) supporting research programmes in documentation, information science, communi cation, computer science, reprography and translation ; and

(21) sponsoring conferences, symposia, seminars, workshops, etc. in documentation information science, computer science, communication, reprography and translation

An essential approach to science information dissemination processes at the national leve is to enrich the information resources and optimise their utilisation by all those who need t use information. In a vast country like India, with a developing economy, federal structur of the government, and autonomy of the provinces, scientific and technological activities ar widely dispersed. A variety of information centres, with differing functions, scope and effi ciency are taking shape in scientific institutions, government departments industrial establish ments, business firms, etc. In a stage of development, they spring up piecemeal, withou liaison between them, without plan, and without coordination, in a somewhat haphazard fashion vever, they function also towards supporting socio-economic objectives, which are national cope. The trend in many countries is to coordinate or marshal a large number of such -sets of information services into a well structured national information system or network. impetus for information network arises out of economic and time pressures which force anisations to share rather than duplicate information resources. Some form of overall or- isation is needed to direct and coordinate the activities of many separate efforts. Some hods must be found out to coordinate the collecting policies of libraries and documentation tres, so that the national collection is shared by all. Information processing should be rdinated in order to eliminate unnecessary duplication of effort. The system must be anised to assure everyone access to information. There shall be no poverty in information ilability. In advanced countries, rapidly increasing stock pile of machine-readable infor- tion has been responsible for the network concepts. The national systems are on the thre- ld of participating in the world-wide, cooperative management of science information under UNISIST (World Science Information System) programme of UNESCO.

1. The establishment of a national information system would embrace the following ectives :

1.1. provision of a national information service relevant to present needs and capable of development to meet the future needs of the generators, processors, disseminators and users of information ;

1.2. optimum utilisation of existing information services and systems and the development of new ones ;

1.3. promotion of national and international cooperation and liaison for exchange of information ;

1.4. support and active encouragement for the development of facilities for education and training in information science and technology, and in communication, to provide qualified manpower for the implementation of the national science information policy ;

1.5. support of, and active participation in, research, development and innovation in information science, and communication, to enhance both the efficiency of information services and the quality of the information provided by these services :

1.6. support and promotion of research, development and innovation in information technology.

2. *Prerequisites of the National Information System.*

The essential prerequisites of the national information system should be the following :

2.1. good communication facilities linking the users to the network of information centres and inter-linking within the nework ;

2.2. more effective use of existing telecommunication facilities and developing new communication facilities for efficient operation of the system ;

2.3. support for scientific publication activities, including the establishment of a national science press ;

2.4. information resources (libraries, documentation centres, etc.) with adequate collection of all types of documents ;

2.5. facilities for training in library and information sciences and communication ;

2.6. good organisational system using modern management techniques and financial p cedures ;

2.7. standardisation in materials, techniques and patterns of service.

3. *Kinds of Information.*

The National Information System should take into account the need for different ki of information. Scientific information, techno-economic information and management inform tion are all appropriate to the needs of a technologically advancing nation. The aim of scient information is to provide information for scientific research. Techno-economic information to provide information for development, production and other economic activities. Mana ment information is to provide planners, administrators and all those engaged in managem of R&D, information relevant to policy framing and decision making. It is obvious that th three spheres of information are not identical. But they intersect each other in many respe and have close links. For supporting scientific and industrial development of a country, e one of them has its importance. The National Information System should, therefore, prov for serving all the above kinds of information.

EXISTING FACILITIES IN INDIA FOR DISSEMINATION OF INFORMATION

1. *Central Bodies.*

The Indian National Scientific Documentation Centre (INSDOC), established in 19 under the CSIR, has been offering national service relevant to the information needs of scient and technologists. Responsive services such as document procurement service, photocopy service, bibliography and reference information service and translation service and anticipat services in the form of bringing out information publications such as the Indian Science A tracts, are being provided by the Centre. It has also taken up several projects for carry out its information dissemination function. One of its major projects is the building up o National Science Library.

The CSIR established the National Register of Scientific and Technical Personnel in 19 to serve as a clearinghouse for information pertaining to Indian scientists, engineers, techn logists and medical personnel at home and abroad.

The Publications and Information Directorate of CSIR has been maintaining a Docum tation Section for collection of information and data on India's raw materials and industr products.

The Library and Technical Information Section of the Bhabha Atomic Research Cent Bombay, has an extensive collection of nuclear science literature and is well equipped provide a wide range of information services. It is participating in the computer-based Int national Nuclear Information System (INIS) of the International Atomic Energy Agen Vienna.

The Library of the Indian Agricultural Research Institute, Delhi is one of our old and biggest science libraries. In 1969, a plan was worked out to establish a national syst of agricultural information, around the facilities available in IARI Library.

The National Medical Library of the DGHS has the responsibility for providing a count wide library and information service in medical sciences.

The Defence R&D organisation has established the Defence Science Information a Documentation Centre (DESIDOC) in Delhi to provide a full range of information servi to scientific personnel in defence establishments.

The Patent Office has recently worked out a plan for the establishment of a Patents ibrary and Information Centre.

The Indian Standards Institution, Delhi, has an exhaustive collection of national standards many countries and is in a position to offer standards information service.

The SIET Institute, Hyderabad, has established a documentation centre for providing formation service to small industries sector.

The Indian Council of Social Sciences Research has established in 1969—the first year its existence—a National Social Sciences Documentation Centre at Delhi. It has already ken up several projects for providing documentation and information services to social scien-sts.

2. *Science Agencies*

Major science agencies such as the Atomic Energy Commission, the Electronics Commis-on, the Space Commission, the Council of Scientific and Industrial Research, the Defence esearch and Development Organisation, the Indian Council of Agricultural Research, the Indian ouncil of Medical Research, the Indian Council of Social Sciences Research, etc. have R&D stablishments functioning under them. These establishments are important centres of scientific nd technological activity in our country. They have developed adequate information base or supporting their R&D programmes. The libraries and information centres attached to nem are subject-oriented. Some of them have developed unique facilities for offering infor-nation services in their fields of specialisation on a national scale.

3. *Central Government Departments*

In addition to the science agencies, several central ministries and departments dealing vith scientific subjects have also research establishments functioning under them. Many of ur older scientific institutions such as the Indian Meteorological Department, and the Geologi-al, Botanical, Zoological and Anthropological Surveys come under this category. They have ich collections of material and are building up information facilities. The Directorate-General f Technical Development has been collecting a variety of information on licensed capacities, oreign collaboration statistics, production levels, etc. of a large number of industrial units. t is presently engaged in processing the data and information through computer.

4. *State Governments*

State Governments are mostly concerned with scientific subjects such as agriculture, orestry, animal health, public health, public works and transport. They may have research stablishments devoted to these subjects. Some of the State Government scientific institutions re in existence for a number of years. Library and information facilities are expected to be vailable in these institutions.

5. *Academic Institutions*

Indian Universities, which are now about 90, are regarded as centres for pure research. Some universities have set up Centres for Advanced Study in special disciplines. Scientific ollections in libraries of some of our older universities are strong.

Agricultural universities are also providing adequate library and documentation facilities.

The Indian Institutes of Technology at Bombay, Delhi, Kanpur, Kharagpur and Madras, he Indian Institute of Science, Bangalore, and the Indian Statistical Institute, Calcutta, are entres for advanced study in scientific and technological subjects. The libraries of these insti-utions are well developed and equipped to provide active information services.

Agricultural, veterinary, medical and engineering colleges are springing up in a large number in various parts of the country. Some of them have facilities for instruction even at postgraduate and doctrate levels and are equipped for carrying out research. They are usually supported by adequate library facilities.

6. *Private Institutions*

Scientific institutions established by private agencies, foundations, individuals, etc. and by learned societies come under this category. Some of them have developed library and information facilities.

7. *Industrial Establishments*

Industries, in public and private sectors, are increasingly aware of the importance of R&D and are taking steps to set up separate R&D units. As a consequence, the importance of documentation and information services is also realised and many of our industrial establishments have set up information centres.

8. *Facilities for Training*

In view of the increasing importance of documentation and information services, qualified manpower to handle information work has become an essential requisite. To cater to this need, postgraduate training courses at Master's level are being provided by the Documentation Research and Training Centre, Bangalore and INSDOC, Delhi.

NATIONAL INFORMATION SYSTEM IN SCIENCE AND TECHNOLOGY IN INDIA (NISSAT)

The NCST, taking these into consideration has recommended that an information system on science and technology be developed with the nucleus of information facilities available in the laboratories of Government scientific agencies and public and private sector industries. It is envisaged that the system will be implemented through a central agency (NISSAT) reporting to the Department of science & Technology.

1. *Planning and Organisational Aspects*

The NISSAT would be based on the existing information facilities. It would develop as an integrated national system by making full use of the information potential of the country, by coordinating the activities and by seeking the cooperation of individual information centres, according to well defined guidelines and division of responsibilities. It may fill up the existing lacunae in information services by establishing new ones. It may develop and apply internationally compatible national standards for information techniques and methods to facilitate interchange of information. It may develop and introduce modern information technology and managerial methods in information work.

The NISSAT would work towards the evolution of National Information Policy. Major science agencies in the federal sector are constituents of the System. An Advisory Committee consisting of science planners, administrators, scientists and information scientists, drawn from science agencies such as the Atomic Energy Commission, the Electronics Commission, the Space Commission, the Council of Scientific and Industrial Research, the Defence Research and Development Organisation. the Indian Council of Agricultural Research, the Indian Council of Medical Research, the University Grants Commission. the Patents Office, the Indian Standards Institution, the Indian Council of Social Sciences Research, the Planning Commission, and other government departments dealing with scientific subjects may be constituted to formulate short-range and long-range programmes, to ensure necessary inputs of men and material, to assign priorities, and to evaluate performance.

2. *Coverage*

The scope of the NISSAT would cover all branches of science and technology, including agriculture, medicine and public health. It would also embrace nuclear science and defence science, as far as non-classified information is concerned. It would also cover patents and standards information.

3. *Structure of the NISSAT*

The functioning of the NISSAT would be in several tiers. The present and proposed national centres of information (NCs) in science and technology, medicine, agriculture, defence science, nuclear science, patents, standards, small industries, social sciences, etc. would constitute the top level of organisation. They are mission-oriented information centres operating at national level. The regional centres of information (RCs) like the Regional Centre of INSDOC at Bangalore, would constitute the second level. The branch information centres (BCs), which are subject-oriented and providing national service are in the third level of organisation. The local information units (LIUs), forming part of individual R&D establishment and serving the specific needs of the users in their parent institutions, are the lowest level of organisation.

The NISSAT is a flexible system, with its components operating under a variety of ownerships and jurisdictions, but collaborating together under the guidance of a coordinating body. What is envisaged is some sort of federation of many scattered and previously existing information centres and libraries and establishing new centres for areas not covered already in order to fill up gaps in information facilities. Where necessary, the existing centres would be upgraded and the facilities augmented. The establishment and maintenance of information centres in the various levels would be the responsibility of the agencies or the institutions to which the information centres belong.

NISSAT will give particular attention to the development of :

(1) a national science information policy ;

(2) techno-economic information facilities for management and decision making and on the application of modern computer and reprography technology to information work ;

(3) documentation of information services in new areas, capable of supporting economic and social development ;

(4) coordinated policy for the information systems of all sectors of national activity ;

(5) national plans for important types of information service, especially mechanised information services ;

(6) information services at all levels (local, branch, regional and national) ; and

(7) a national network of mission-oriented centres of information.

3.1. *National Information Centres (NCs)*

The NCs are responsible for coordinating, organising and providing information at national level for large sectors of national endeavours. They are mission-oriented centres. The NCs may have the following responsibilities under the NISSAT :

(1) Planning and coordination activities of BCs coming under their jurisdiction ;

(2) Developing and maintaining document collections, serving as the national base for information work ;

(3) Promoting cooperative acquisition of foreign literature ;

(4) Compiling national union catalogues of collections available in their sectors ;

(5) Maintaining data banks, containing data relevant to the activities and the development of the sector ;

(6) Bringing out current awareness services on Indian scientific literature and on selected foreign literature either bearing interest for several branches or fields where BCs do not yet exist ;

(7) Providing translation service ;

(8) Procuring copies of documents, on request, from whichever source available ;

(9) Providing reprographic facilities for copying documents and distributing information ;

(10) Organising information dissemination services, including data retrieval, based upon their own holdings and data, and on the utilization of information services available on magnetic tapes ;

(11) Organising training facilities in information science, documentation, computer science, reprography, translation, etc. ;

(12) Carrying out and supporting research in documentation, information science, computer science, reprography, translation, etc. ;

(13) Providing advisory services to RCs, BCs and LIUs ; and

(14) Developing relations and cooperation with foreign documentation and information centres.

3.2. *Regional Information Centres (RCs)*

The establishment of RCs will help in utilising fully the literature resources available in various parts of the country. India being vast, one national centre alone cannot effectively exploit literature resources scattered all over the country. By establishing RCs in major centres of scientific and technological activity, it would be possible to aim at a greater utilisation of our literature resources. In major cities, science libraries are concentrated and scientific collections are rich. Science libraries in our country are gradually developing their collection and they should be fully exploited for the benefit of the entire scientific community. It would, then, be possible to minimise our dependence on foreign documentation centres for procurement of copies of documents required by scientists.

The RCs are not subject-oriented. They would cover all branches of science and technology including Agriculture and Medicine. INSDOC has established a Regional Centre at Bangalore and it is offering documentation services since 1964. INSDOC has drawn up proposals, for establishing during the Fifth Plan period, regional centres in Hyderabad, Bombay, Calcutta and Madras.

The main objectives of RCs are :

(1) to survey the information sources of the region and to organise their mobilisation for meeting the information demands of the region ;

(2) to establish, maintain, update and publish regional union catalogues of literature resources ;

(3) to establish a strong reprographic unit and to serve the region with reprographic copies of information sources; and

(4) to procure, on request, documents within and outside the region.

3.3. *Branch Information Centres (BCs)*

Information and data work requires institutional support, access to information resources and reprographic facilities. BCs which are subject-oriented (mission-oriented or discipline-oriented) would, therefore, be developed from the most suitable LIU, having already developed strong information base. They would serve all institutions in the discipline of the branch. They would form a channel for disseminating information between the NCs and LIUs. In order to progress from workshop to industrial level and thus render valuable service to a larger community of users, these centres need to be encouraged, supported and articulated.

The inputs required for the operation of the BCs may have to be provided by the institutions to which they belong. The centres would be staffed by science trained officers. Their services are expected to play an essential part in the flow of information, by maintaining close touch with current scientific and technical research and practice and by continuing close association with the users. The BCs would create information banks in their areas of specialisation. They would select, evaluate and synthesise information in well defined special fields and/or in areas pertinent to specific missions and present it in a form best suited to the needs of users, either in research or technology or management.

The BCs would be entrusted with the responsibility for coordination of information services within a branch. They may promote the creation and development of LIUs by offering advisory services and assistance in information systems analysis, design, etc. They may also develop and maintain relations and cooperation with foreign information centres and professional bodies in their branches.

The main role of BCs is to provide following information services :

(a) specialised current indexing and abstracting services including SDI (Selective Dissemination of Information) services ;

(b) Subject bibliographies ;

(c) Subject union catalogues ;

(d) Information retrieval on request ;

(e) Information on patent specifications and standards, etc ;

(f) Information on scientific, technical and economic data ;

(g) Preparation of surveys, state-of-art reports, scientific and technological forecasting, and other types of techno-economic and special management information service.

The BCs would build up and maintain a document collection supplementing those of the institutions in the Branch. The BCs would build up data bank relevant to the scope and activities of the Branch. They would envisage developing computer based information services for the branch, in cooperation with NCs and assuring national and international compatability. The services would be based partly on processing of Indian and foreign literature and on retrieving data from their own data banks but chiefly on utilising existing and future specialised information services available on magnetic tapes.

To begin with, BCs could be developed in major industrial disciplines. The developme of BCs for at least ten areas is suggested for being taken up during the Fifth Plan perio BCs can be set up at the CSIR laboratories for the following subjects :

Metallurgy
Chemical Technology
Leather Technology
Food Technology
Aeronautics
Electronics
Mechanical Engineering
Petrochemicals
Pharmaceuticals
Glass & Ceramics
Mining Industries
Coal
Public Health
Oceanography
Medicinal Plants
Building
Road
Instrument Technology
Cement
Textiles
Tea
Jute
Rubber
Paints
Wool

Preliminary work has already taken place for developing adequate information base capable of providing national service, in the National Aeronautical Laboratory, Bangalore, th Central Food Technological Research Institute, Mysore, the Central Leather Research Institute Madras and the National Metallurgical Laboratory, Jamshedpur. Therefore, the developmen of BCs for Aeronautics, Food, Leather and Metallurgy could be taken up in the first phas itself around the nucleus of the facilities available in these laboratories. Additional areas suc as Fertilisers, Transport, Building Industry, Heavy Engineering, Petrochemicals and Mining ar also suggested for being taken up in the Fifth Plan, for creating the BCs.

An Electronic Information Centre is already in operation under the auspices of the Electronics Commission.

3.4 *Local Information Units (LIUs)*

The LIUs (Special libraries, Information centres, etc.) operate in scientific institutions government agencies, industrial enterprises, business firms, etc. Their number may be estimated to be around 600 at present, and more are springing up. They are of varying scope, standard and efficiency. The LIUs are the ultimate recipient of information from NCs and BCs. They are expected to offer personalised service in anticipation of, and against specific requests, by providing scientific, technical and economic information necessary for the functioning of their parent institutions. Their services are directed towards work in progress in their institutions. The LIUs are also responsible for feeding information generated by their institutions to BCs and NCs.

MAIN ACTIVITIES AND SERVICES

1. *Information Needs and Uses*

There has been a lack of precise knowledge on the real needs of users of scientific and technical information. It is essential, in the first instance, to obtain information relating to the known and anticipated needs of users and the resources currently available to meet them. A survey of information needs and uses and the resources available has to be undertaken so as to plan the functioning of the NISSAT in the context of actual need and uses and to build up adequate resources for meeting them.

2. *Acquisition*

A policy for coordinating the acquisition of documents and their distribution among different libraries is essential and urgent in order that the libraries do not have unnecessary tock, that there is no undue duplication of material among libraries and that the available ook purchase fund of the country is allowed to go the longest way for acquiring maximum umber of titles. The acquisition policies and profiles of each institution should be clearly efined and coordinated within the branch, within the region, and at national level. The co-rdination may include mutually agreed acquisition profiles of institutions and subscription to eriodicals and serials.

Most important of the material should be available in the institutional libraries for irectly meeting the requirement of their users. The BCs should supplement the acquisition f individual institutions coming under its purview, with highly specialised and costly material, he use of which will be shared by all institutions in that branch. The BCs would be responsible or collection and deposit of unpublished literature such as research and development reports, rade literature, etc. The BCs would in effect be the coordinating agency for acquisition of naterial for the institutions coming under them.

The RCs would build up a collection of general works and maintain a general reference ibrary. They would collect and hold thesis and dissertations prepared within the region. They would act as regional coordinating agencies in the National Cooperative Acquisition rogramme.

The NCs would build up national collections, by complementing the branch and regional collections and by filling up areas not covered by them. A large reference library and a collection of indexing and abstracting services would be the core of the collection in NCs. They would take in a large number of periodicals by way of filling up gaps in national acquisitions. They would also specialise in acquisition of foreign language literature, not being presently received to the desired extent by institutional libraries. They would also maintain depository of Indian scientific material in areas of their mission. In this connection, establishment of the National Science Library, the National Medical Library and the National Agricultural Library, deserves mention.

In the matter of building up our national collection, the goal would be that the libraries of NCs, RCs, BCs and individual institutions, taken together should ensure that at least one accessible copy of everything worthwhile published in the world, is being made available within the country itself, no matter where it is kept, for use by our scientists at all times to come.

3. *Union Catalogue*

Setting up a decentralised network means that the constituent libraries must use common techniques for processing their collections. This is essential for the purpose of interconnection and as a tool for readily locating documents in our libraries. Efforts are needed to induce the various institutions to share in the preparation of the national union catalogues, so that they can be made complete and uptodate. In this connection, INSDOC has already initiated a Project for Compilation of the National Union Catalogue of Serials. The compilations, so far brought out, cover nearly 350 libraries. INSDOC has also developed programmes for compiling the union catalogues through computer.

Besides serving as location tools, union catalogues help in revealing strong and weak areas of our national collections. They would also be of help in coordinating our acquisition programme.

Towards the ultimate object of compiling national union catalogue, the following types of union catalogues may be of importance:

(a) Regional Union Catalogues, containing the integrated holdings of a region, prepared, maintained and published by the RCs; and

(b) Subject Union Catalogues, containing the integrated holdings of a Branch, pre pared, maintained and published by the BCs.

4. *Data Banks*

The NCs and BCs would build up data/information banks relevant to their activitie The data bank in NCs will collect information on:

4.1 R&D activities in all the agencies and the departments and the laboratories;

4.2 Completed projects from these organisations available for commercial exploitation;

4.3. Status of technology abroad;

4.4 Status of R&D in developing countries, R&D country profiles;

4.5 Management information;

4.6 Manpower;

4.7 Industrial processes, licences issued, joint ventures, production;

4.8 R&D expenditure;

4.9. Infra-structure available for R & D;

4.10. Statistical data; and

4.11. Information systems available in the country, subject-wise, industry-wise region-wise.

In addition, there would be also discipline-oriented data banks, created in the BCs. These banks will select useful information, analyse it with user interests and store it either in a conventional or a machine-readable form.

5. Current Awareness Service

5.1 *Indian literature*

Monographical literature is expected to be covered comprehensively by the Indian National Bibliography. As regards microdocuments, the examples of the Indian Science Abstracts and the index to Indian Medical Periodicals, which are currently being brought out by two national centres, *i.e.* INSDOC and the National Medical Library may be cited. Other national centres may also bring out similar publications for the purpose of effective bibliographical control of Indian scientific literature. National indexing and abstracting services act as a feeder for coverage of Indian literature in major international abstracting and indexing services and they should, therefore, be promoted. For example, BARC is preparing the Indian input to INIS. Such a cooperation is also expected of us in the UNISIST (World Science Information System) programme of UNESCO.

Control of unpublished literature should be taken care of by the BCs, as it has to be further procesed for being made use of. However, thesis could be collected, processed and indexed more effectively by the RCs.

5.2 *Foreign literature*

Indexing and abstracting services, devoted to foreign literature and with universal coverage, for the purpose of providing current awareness service to our scientists, is neither necessary nor feasible at national level. In all major disciplines and branches of knowledge, international indexing and abstracting services are available and they can be made use of by BCs and LIUs for preparing selective current awareness services. However, the NCs may have to take care of those areas that cover the interests of many BCs. For example, the various information publications being brought out by INSDOC for dissemination of Russian science information and the Current Literature on Science of Science may be mentioned.

Indexing and abstracting services are now increasingly available on computer based magnetic tapes. For example, CA tapes for Chemistry, COMPENDEX for Engineering, INSPEC for Physics, MEDLAR for Medicine and Agricultural Index are available. More and more of such services are being brought out. In NISSAT, it is proposed that the acquisition of such costly tape services should be centralised at the national centres. However, the services to be generated from them would be available to BCs who may, in turn, select, evaluate and synthesise information for transferring it to the users. It is hoped that the NCs would have their own computer facilities for this purpose.

6. *Selective Dissemination of Information Services (SDI)*

The SDI services are expected to provide information which as closely as possible meets the interest profile of the user. The aim would be to furnish to the user not only titles and bibliographic reference but analytical abstracts of documents as well. Whether these services are performed manually or with a computer, their development is of prime importance. They can supply widely scattered users with the new knowledge they need to keep abreast. They also constitute a means of making information conscious potential users, who had so far been unaware of its importance.

7. *Information Analysis, State-of-the-Art Reports, Surveys, Forecasts*

Users, who are industrial and technological fields, need carefully selected data of practical importance and relevance. They need digested information, in a manner in which it could be straightaway assimilated and used. What they need is information and data which are immediately applicable to their work, or which can help to solve the problems they face. In these cases, information has to be analysed in detail, keeping in view the interests of the users, and served promptly. The users are not satisfied with raw data or mere bibliographical citation of pertinent literature. They want the actual information. For this purpose, the source documents have to be analysed and pertinent information culled out and served. This type of work is expected of BCs.

Reviewing the state-of-art in particular fields is also to be undertaken by BCs. Such reviews have to be prepared for three levels of users—the research scientist, the industrial research engineer and the production engineer. This service helps the users to be posted with the current advances being made in their specialities.

8. *Information Service to Industry*

In a country with so large a number of small and medium-sized enterprises—often cut off from all sources of information—it is essential that the Industries are provided with easy access to scientific and technical information, if they are to develop and contribute more actively to the national economy. The industries have to be first of all convinced that they need information. Then, they have to be helped to find relevant information. Finally, they have to be advised as to how best to apply the information. Here again, the industries would require information in a manner in which it could be straightaway assimilated and made use of. Mere supply of raw scientific information would be of no avail to them. They are more in need of practical know-how, in techno-economic context. The information to be served has to suit their practical needs. For example, providing information about a manufacturing process for which raw materials are not easily available in the place of location, is of no consequence. Most of our small and medium-sized industries do not employ qualified persons and they are not in a position to use raw information. The information to be served has to be well digested and capable of being applied directly towards practical ends.

The establishment of the Documentation Centre of SIET Institute, Hyderabad is a step in the direction of offering industrial information services. The NISSAT has a Major role to pla in industrial information service. The present efforts of various small scale industries institution in the country would be also integrated so that flow of information to small firms is ensured

9. *Referral Service*

Information may not have been always published. It may be held in one of the thousand of files and data banks. Those files are only partially used, because of their being unknown t the public. Some effort should be made to publicise the location and content of these sources. Sometimes, information can be obtained quite easily from specialists in the field concerned. A service must be provided to know who the specialist is and where to find him. Those who are in need of information should be able to know as to which sources they should consult. More often, they may have no precise knowledge as to the source where from they could seek information. A referral centre, where an inventory of all types information sources in the country is maintained, would therefore be set up to direct the enquirer to the sources of information, for purpose of establishing contact quickly.

A—*Budget of NISSAT*

The total outlay (capital & recurring) over the fifth plan period is estimated at Rs. 15 crores out of which Rs. 4 crores is in foreign exchange.

The expenditure is likely to be phased as follows:

Plan Year	74-75	75-76	76-77	77-78	78-79
Outlay (Rs. in crores)	1	1.5	4.5	4	4
	Groundwork		Growth	Consolidation & Divestment	

The sum of Rs. 15 crores budgeted for NISSAT includes the design and construction of buildings, fixed installations and peripherals but excludes the cost of computers. In the last year of the Fifth Plan when the network is consolidated, individual units of the network will be handed over to their respective parent organisations. Thus about 25 percent of the facilities will be divested to the individual organisations by the end of the Fifth Plan. Their recurring expenses will appear as non-plan (VI Plan) expenditure of the respective organisations. In the VI Plan NISSAT itself will have a Plan outlay not exceeding Rs. 5 or 6 crores.

The proposed outlay for NISSAT amounts to just under 1 per cent of the Plan outlay of the Science & Technology Plan. The tentative break-up of this outlay among the major sectors is given below. The figures exclude the cost of computer installations.

(Rs. crores)

No.	Sector	Plan outlay	Foreign Exchange component
1.	Natural Resources, Meteorology & Atomospheric Sciences	4.0	1.5
2.	Information base for integrated development of rural, urban and regional systems	1.0	0.2
3.	Engineering industries & construction	3.0	0.5
4.	Other industries	2.0	0.3
5.	CSIR and National Medical Library	3.0	1.0
6.	General (DGTD, Patents Office, CSO etc.)	1.0	0.1
7.	NISSAT Agency :		
	Design & Development Contracts for information technologies	0.5	0.3
	Education & Training	0.3	0.1
	Planning & Administration	0.2	
	Total	15.0	4.0

0. *Promoting Use of Information*

The importance of information in research, development, production and other human ctivities has been stressed upon earlier. It has also been described that information is a ital national resource. Information, therefore, ought to have its market so as to derive its llest benefits. There is need to create and step up demand for information by all those ho are concerned with national development. The NISSAT has to find ways and means to ake potential users, information conscious. It is an essential step even for the growth of the ISSAT. By stepping up demand for information, there is a possibility of our information ervices being placed on a self-supporting basis and thereby depending less and less on government support.

Oral communication between information specialists and potential users of information, rganising group discussions, demonstrations, seminars, etc., and establishing personal contacts re a few measures adopted for promoting use of information.

Proper facilities for training in the use of scientific information have to be also organised. The training will help to improve the user's attitude to information and would promote use of nformation. It will be of help specially to those who are entering research career.

1. *Training in Information Science*

The NISSAT has to take care of the manpower requirements for its efficient and proper unctioning. In view of the growing demand for information services, the rapid advances in nformation field, the advent of computerisation of information systems and their extension t national and international levels, the country would require not only an adequate number f qualified information specialists but also managerial staff with broader training to plan, irect and administer new information systems.

2. *Research in Information Fields*

Documentation and information science have been making great strides in recent years and have revolutionised the concepts in regard to the services expected of them. Information field has become a fascinating for undertaking research. It offers a great scope for innovation and development. The importance of research in this field is increasingly being realised and advanced countries are making great efforts. India has also been making notable contributions especially in classification efforts. The role of Documentation Research and Training centre is significant in this connection. The NISSAT has responsibility for promoting research in information field.

SUMMARY

Scientific information forms an important infrastructure for technological and industrial development of a country. Scientific information has, therefore, to be considered as an important national resources to be developed and made available to those who need it. This national resources has to be strengthened and coordinated, and all its components should be considered holistically as a part of the national system. Building up of a strong national information infrastructure would enable us to take full advantage of the World System of Scientific Information (UNISIST) the main objective of the national information policy will therefore be to provide research workers, scientists, engineers, management personnel, etc. with rapid access to information. To develop this economically, the national system will make full use of the information potential already available in the country, by seeking the cooperation of all information centres according to well-defined guidelines and responsibilities. The functioning of the system would, therefore, be at several levels, *viz*., national centres of information, regional centres of information, branch information centres, and local information units. Active participation of all science agencies in the federal sector is a *sine qua non* for achieving an integrated national information system for science and technology.

SECTOR-ENVIRONMENTAL QUALITY

ENVIRONMENTAL QUALITY

Introduction

1. *Technology and the quality of life*

In her speech to the UN Conference on the Human Environment at Stockholm in June 1972, Prime Minister Indira Gandhi observed :

> "The environmental problems of developing countries are not the side effects of excessive industrialisation but reflect the inadequacy of development. . . the higher standard of living must be achieved without alienating people from their heritage and without despoiling nature of its beauty, freshness and purity so essential to our lives".

The NCST echoed this sentiment in its Approach Document when it noted : "... there is more to development than a mere quantitative increase in production. . . . development is thus more than just growth : it encompasses the spectrum of total human betterment..."

The NCST reiterates that without the use of technology poverty cannot be eradicated. And "the environment cannot be improved in conditions of poverty". However, in attempting to eradicate poverty through employment-creating technology, we have not, in the past, paid adequate attention to the quality of the lives of those who gain employment and these they support—directly or indirectly—from industrialisation. Thus the conditions in the slums in and around our cities are appalling in the extreme. In attempting to use and exploit our natural resources we have not ensured that we do not "despoil nature of its beauty, freshness and purity". Nor have we been careful about where and how we discharge our industrial and domestic effluents or how noisily we produce and deliver our goods, services and entertainment. While we have been concerned about protecting our crops from pests, we have largely neglected to take account of possible poisoning by the pesticides we use.

2. *Policies and research in pollution control and environmental improvement*

It has been suggested that concern for the environment is a luxury which poor nations cannot afford. There is not necessarily a conflict between economic growth and environmental quality. Indeed, measures to ensure a qualitatively better environment may stimulate the growth process. The question of whether or not a particular set of measures should be put into effect is a complex issue involving many different economic, social and political consideration. The measures of policy, planning, administration and legislation needed to control pollution, and to effect an improvement in the environment, are the allotted business of the National Committee on Environmental Planning & Coordination (NCEPC). It is not the purpose here to detail these measures or the underlying issues. The NCST believes, however, that the technological knowledge and the means to control pollution and to effect an improvement in the environment should be ready at hand whenever the decision is made to deploy them. Accordingly, the NCST has interacted closely with the NCEPC and with it identified a number of areas where research, both basic and applied, is badly needed to provide the knowledge to underpin rational measures to ensure a healthy environment.

The research programmes fall into four main areas: environmental aspects of human settlements; environmental aspect of natural resources management; environmental pollution; and research, training and education in ecology and environmental sciences. The programmes on Environmental Quality are intermeshed with those of the sector on urbanisation of the panel on Housing, Urbanisation and Construction Technology; as well as the panel on Waste Utilisation.

The Total outlay in the above areas is estimated at about Rs. 17 crores, over the fifth plan period. The whole of the amount has been tentatively shown in the plan proposals of the Department of Science & Technology (DST) although only programmes worth about 60 per cent of this amount are expected to be sponsored by the DST through its Office of Environmental Planning & Coordination (OEPC). It is expected that the rest will be taken up by the various implementing agencies.

Environmental aspects of human settlements :

The work in this area has been closely interlinked with the programmes envisaged under Panel 15 : Housing, Urbanisation and Construction Technology. The emphasis in this panel is on upgrading the environment while that in panel 15 is on rural, urban and regional planning and development (both software and hardware development).

The problem of the urban environment in Indian towns and cities is not one of excessive industrialisation or solely one of urbanisation but is that of a developing economy and of organising urban areas for providing people with public amenities, utilities, facilities and services, compatible with natural surroundings. Practically no research work has been done in India on urbanisation in the context of our patterns of living, a developing economy and future settlement patterns. Intensive research and development work is urgently needed at the following levels:—

1. *Metropolitan Towns*: The deterioration of the living environment in metropolitan cities like Calcutta, Bombay and Delhi has reached an alarming stage. Although significant efforts have been made in the past to organise the cities, they have resulted in piece-meal solutions and spot developments which lack basic public amenities, utilities and services.

On the other hand, medium size cities like Madras, Kanpur, Ludhiana, Kotah, Ahmedabad and Bangalore have started expanding because of rapid rate of industrialisation needed to improve the economic base of the regions. It is being emphasised time and again that Kanpur may become another Calcutta and Ludhiana may become another Kanpur in the near future.

The major problems of physical environment in these cities can be listed as :

(a) Unorganised land-use systems in the context of Indian living patterns.

(b) Inadequacy of public utilities, services and amenities.

(c) Slums, squatters and pavement dwellers.

(d) Large-scale suburban sprawls.

(e) Ever-increasing urban blight.

(f) Increasing rate of social evils, traffic accidents, underemployment and unemployment.

2. *Existing towns* : We have in the country a large number of dilapidated towns deteriorating because of lack of an intensive economic base: for example, towns like Hapur, Muzzafarnagar, Roorkee, Rohtak, Karnal and Sonepat, which need to be reinforced economically. In the context of ever-increasing urbanisation—the urban population is assumed to increase from about 79 million in 1961 to perhaps 300 million people in the year 2000—it is essential that a significant effort is made to concentrate new urban areas in and around these dilapidated town to provide them with an economic base and to reduce the number of new towns for better conservation of resources.

Work is needed in identifying towns of potential location and for finding out appropriate houses o be located in these areas.

3. *New Towns* : It has been estimated that we shall need almost 500 new cities by the year 2000. Assuming that a large number will be or could be accommodated in or around the existing owns for locating major industries, ports or for other projects, R&D work needs to be done in identifying and setting criteria and parameters of human settlement patterns particularly from the point of view of optimum utilisation of available resources and efficiency of the urban structures. (This is covered under Panel 15).

4. *Urban Development Renewal* : Our cities have started deteriorating in the central areas because of economic activities located outside the core areas. This particular change is not desirable because of the availability of urban infrastructure, resources and manpower in the central areas. The new job centres located away from the centre remain undeveloped for a sufficiently long time, until they grow into viable new areas offering similar facilities, opportunities and resources. This means duplication of public investments, ignoring the resources available in the centre and generating the same resources in the new centre. Work is needed in the field of urban structuring.

5. *Landscaping of urban areas* : We need to compile a bibliography of commonly available tree-plants, shrubs and ground-cover suitable for various regions. R&D work in this context should also include maintenance cost, time factor, tree plantation techniques and improving the irrigation systems. This is an important head and needs serious consideration in view of the microclimatalogical effects on the urban environment.

6. *Transportation* : The movement of goods and people within a city is a major problem. Very little research work has been carried out into transportation networks in our country. Intensive R&D work is needed on survey and analysis techniques and mass transit systems. The programmes under this category are interlinked with programmes under Panel 9 (Transportation) and 15.

7. The research programmes in this area cover the following categories :—

No.	Area	Outlay (Rs. Lakhs)
7.1	Settlement Planning & Management	175
7.2	Land use	65
7.3	Transportation Planning	45
7.4	Water supply and sanitation	
	(i) Water supply	80
	(ii) Drainage & waste disposal	120
	TOTAL	485

Environmental aspects of natural resources management :

The research programmes in this area cover the following categories: environmental problems in agriculture and soil use; forests; wildlife and mining and metallurgical industry.

1. *Agriculture and soil use* : The projects in this category dovetail into but do not overlap or duplicate work envisaged under the ICAR or Ministry of Agriculture.

The indiscriminate use of pesticides not only causes poisoning (this is treated separately in area 3) but becomes ineffective and even counter-productive after a time as the pests develop resistant strains and their predators are destroyed. One requires to deploy a combination of chemical pesticides and biological control to achieve optimum control of pests. Research is needed to determine the parameters that influence the optimum combination in different conditions

As our population expands, the intensity of agriculture to feed it has also to rise. The long term effects of large-scale irrigation are little understood but enough is known from meticulous historical studies to warn that, unless we embark upon research to understand and thence to control the ecological problems arising from intensive agriculture, we will lose the very resources we depend upon to feed our people. To requote Allan Octavian Hume—the founder of the Indian National Congress— "...come it quickly or come it slowly, the ultimate resul here is also certain, and, unless a radical change is effected in existing arrangements, we know, as definitely as we know that the sun will rise tomorrow, that the time must come when some o the richest arable tracts in Northern India will have become howling saline deserts."

2. *Forests* : The two projects here do not duplicate the research programme detailed in the natural resources sector.

3. *Wildlife* : The research programme is designed to underpin the work of the National Wildlife Board and to secure foreign exchange earnings through the export of skins.

4. *Mining and Metallurgical Industry* : Mining and smelting operations are particularly harsh on the environment with unacceptable detrimental effects on the health of the people working in these industries. The research programmes in this category are designed to alleviate some of the major environmental problems in these industries.

5. The outlays for the programmes are as below :

No.	Area	Outlay (Rs. Lakhs)
5.1	Agriculture & soil	100
5.2	Forests	30
5.3	Wildlife	30
5.4	Mining & Metallurgical Industry	40
	TOTAL	200

Environmental pollution control and abatement

The four categories in this area are : water pollution; air pollution; pesticides and noise.

1. *Water pollution* : The problem of water pollution is one of the major factors in the poor quality of the human environment in India. The hazards of unsafe drinking water and pollution of water caused by the discharge of untreated industrial and sewage effluents is increasing both in quality and quantity throughout the country. In view of the urgent need for a comprehensive enactment for effective control of pollution and water management the Prevention of Water Pollution Bill was introduced in the Parliament in 1969;

> "To provide for the prevention of Water Pollution and the maintaining or restoring of wholesomeness of water, for the establishment, with a view to carrying out the

purposes aforesaid, of Prevention of Water Pollution Boards, conferring on such Boards functions relating thereto and for matters connected therewith".

The Bill is awaiting Parliamentary approval. In order to provide the necessary information o set standards, monitor and adequately police the adherence to the provisions of the Act-to-be, a great deal of survey, measurement and analytical activity will have to be undertaken. The programmes include projects designed to underpin possible comprehensive water-management egislation (covering also coastal pollution) that may be enacted in the near future.

2. *Air Pollution* : Inasmuch as the levels of energy usage, industrial activity, population density, transportation, together with such factors as topographical and climatic conditions, have a significant bearing on the composition of atmospheric pollution, it is true that, with some localised exceptions, the problem has not thus far acquired in India the critical dimensions it has attained n more industrialised nations like the USA, USSR, UK, Germany or Japan. Nevertheless, the nature of this problem, with the delays inherent between decision and results, suggests the importance of early and detailed examination to ensure prudent management of a vital resource.

2.1 *The nature of air pollutants* : The atmosphere plays temporary host to a large number of substances, each with a variety of origins, undesirable effects, and mechanisms for removal. The more common among these are :

The compounds of Sulphur : Levels of 0.1 ppm can cause corrosion of stone and steel. Protracted exposure at concentrations of 1 ppm can be fatal.

The oxides of Nitrogen : These are produced by high temperature combustion such as in internal combustion engines. At levels of 1 ppm the oxygen transport capacity of the blood is significantly reduced. Under the influence of sunlight, these can form substances which irritate and damage the eyes and lungs and vegetation.

Hydrocarbons : These can be carcinogenic.

Carbon monoxide : A highly poisonous gas, symptoms of toxicity appear at concentrations of 20 ppm or lower.

Suspended particles : These arise from industrial sources, forest-fires and agricultural burning. This category includes light aerosols, tar, carbon particles (smoke), pollen and fly-ash. Health hazards, loss of visibility and general nuisance occur when particle densities reach 1 mg/cu.m.

2.2 *The sources of pollutants* : The activities which are responsible for air pollution can be grouped into five major categories.

Thermal power generation : The use of high ash-containing coal middlings to fire the boilers of almost all thermal power stations in India leads to considerable problems with particulate emission. Abatement technology, particularly mechanical collectors and electrostatic precipitators are being increasingly installed, but installation is apparently not always followed by sustained use. Although more costly, washers and scrubbers, and chemical treatment plants can be used where particularly noxious flues are emitted. Higher stacks and better location are available for further reductions in the local concentrations of particulates.

Projected thermal electricity generations is expected to more than triple from approximately 30 x 10^9 KWHr in 1971 to over 100 x 10^9 KWHr in 1980. The corresponding figures for coal usage in power production are 17 million tonnes and 60 million tonnes. Environmental considerations must, therefore, be fully taken into account in the planning of new capacity.

Transportation : Public transportation buses, at present responsible for a good part o the urban air pollution problem, should be cleaned up. Railways, too, are guilty in this matter A recent study of pollution levels in Nagpur finds that over fifty per cent of the particulates and sulphur oxides in the city's air originates from the railways.

Industries : Industries such as Iron & Steel, Non-ferrous metals, Petroleum refining, Petro-chemicals, Cement and Paper & Pulp occupy the front rank in their prepensity to omit atmospheric pollutants. Cement dust is responsible for the complete destruction of large tracts of land surrounding the producing units.

Domestic and commercial activities : The use in India of non-commercial fuel (consisting mainly of fire wood, cow-dung and vegetable matter) as a percentage of total fuel usage is very large, though steadily decreasing. From 70 per cent in 1950, it had fallen to about 50 per cent cent in 1970, however, because of the large increases in total fuel consumption, the absolute quantities burnt of non-commercial fuel have more than doubled during this period, from 80 MTCE (million tonnes of coal equivalent) to 180 MTCE. In 1980, it is estimated that 220 MTCE of non-commercial fuel will be consumed, 150 MTCE of which will come from fire-wood charcoal.

Pollution due to domestic fuel burning and open-air coking is one of the problems which has assumed major proportions in some parts of the country. It is often accentuated by low level atmospheric inversions. Dangers to health and vegetation have on occasion caused some alarm.

A large part of this problem, especially in urban areas, results from carbon monoxide (burning of wood and coking), acralein (burning of cow-dung), and tar (burning or coking of high-bitumen content coal). For example, one factor in Calcutta's pollution problem is the domestic use of 2,000 tonnes of coal a day. Since half of its bitumen content (20-30 per cent) goes straight into the air, about 1 tonne of tar ends up by being deposited daily on every square kilometre of the city.

It should also be remembered, that in addition to generating air pollution, use of non-commercial fuels has other serious environmental and economic repercussions. The burning of cow-dung disrupts several natural nutrient cycles. The burning of wood can entail indiscriminate clearing of forests with consequences of soil erosion, habitat destruction, and loss of wood which could be used for other purposes.

Table I shows the atmospheric concentration of air pollutants in some major cities.

TABLE I

Pollutant	quantity	Ahmedabad	Calcutta	Delhi	Jaipur	Kanpur	Madras	Nagpur
Sulphur dioxide .	average	0.004	0.015	0.022	0.002	0.030	0.011	0.004
(ppm)	maximum	0.010	0.066	0.130	0.005	0.060	0.018	0.013
Nitrogen dioxide .	average	0.005	0.017	0.008	0.003	0.004	0.014	0.013
(ppm)	maximum	0.011	0.056	0.019	0.007	0.012	0.050	0.031
Hydrogen sulphide .	average	—	—	0.0002	—	—	0.004	—
(ppm)	maximum	—	—	0.001	—	—	0.016	—
Suspended particulates	average	0.342	0.350	0.631	0.439	0.591	0.060	0.302
(mg./cu.m.) .	maximum	0.505	0.663	0.997	0.114	1.567	0.103	0.546
Dustfall rate . .	average	196	25	106	85	114	—	92
(tons/mile^2/month) .	maximum	283	37	195	101	283	—	40

Details are not given on the significance and comparability of these results. Since they vary with the time and duration of observations, sampling techiques, types of equipment, and the position of the sensor (especially its height above ground), the numbers given above should be taken only as being approximate.

2.3 *Research on air pollution* : The thrust of the programmes is to provide reliable data on the extent and types of air pollution and to study its effects with a view to setting air quality standards and specifications for pollution abatement equipment and other control measures.

3. *Pesticides*

3.1 *The problem* : Although pesticides have played, and will continue to play, a major role in the control of a wide variety of insect pests in agriculture, veterinary and public health, their large scale indiscriminate use has posed some threat in localised situations to other forms of life and to a certain extent upset the natural ecological balance in the environment. The use of agrochemicals including pesticides will have to continue for production and protection of crop plants. Indian agriculture has reached a stage where the focus of the attention is about to shift from high yielding varieties of seeds and optimum doses of chemical fertilizers to adequate crop protection. The Indian farmer is poised for a remarkable increased use of pesticides for crop protection during the coming years.

The major use of pesticides is in agriculture followed by public health. In veterinary practice and in forestry the use of pesticides is still limited. As against an estimated consumption of some 30,000 tons of technical grade pesticides in agriculture in the year 1971-72, the public health programmes are reported to have used about 5,000-6,000 tons. In agriculture the pesticides are used for treating seed, soil, standing crops in the fields as well as the harvested produce in the stores/godowns/warehouses. Of the above categories the bulk is used for spraying and dusting of crops. The seed dressing materials and rodent-control chemicals are used in very small quantities, approximately about 500 tons.

As is to be expected, the large range of pesticides being used in the country includes pesticides differing in their mammalian toxicities and other properties of efficacy, bio-degradation and persistence. Whereas insecticides like parathion, phorate, aldrin, phosphamidon belong to the very highly toxic class of chemicals, malathion is considered relatively safe. The open door policy in the country naturally encouraged foreign manufacturers to export and popularise, rather indiscriminately, highly toxic pesticides as they prove to be the most effective and economical. The present approach will need re-appraisal in the light of recent happenings and new knowledge. The situation is particularly difficult as the Indian farmer has begun with a most effective, and therefore most toxic and invariably, the cheapest chemicals and would find it difficult to give them up in favour of safer but perhaps less effective and generally more expensive chemicals at about the time when profitability of the plant protection measures is just beginning to become apparent to him.

3.2 *Sources of environmental pollution by pesticides* : The pollution of the environment by pesticides takes place through air, water and land. Until recently air pollution due to pesticides occurred around the pesticide manufacturing and formulating units and to a limited extent on and around the farm land. However, extensive use of aero-chemical means to control crop pests has increased the possibilities of air pollution over a wider area. There is an urgent need to determine the extent of pollution by this means. During the last three years the areas receiving pesticides with the help of aircraft has increased from 4.43 lakh hectares to 10.91 lakh hectares in 1971-72. Cotton and paddy were the main recepients with 2.44 and 2.67 lakh hectares. The pesticides which has been used (phosphamidon, dimethoate, aldrin, toxaphene, methyl-o-demeton, malathion etc.) also vary considerably in their inherent toxicities. During the Fifth Plan the areas receiving pesticides from the air is to rise to 30 lakh hectares. Ground spraying of tall trees and tall crops does also contribute to air pollution but the extent is rather limited.

The pollution of water by pesticides generally occurs with the dispersal of pesticides in surface water from the target areas to non-target areas as direct addition of pesticide like DDT to water surface is resorted to only for the control of malaria/filaria mosquitoes. In a localised situation, drifts can contaminate lakes and water streams. The contamination of water-ways by pesticides has been low although there have been instances of economically important fish dying from agricultural pesticides.

The major cause for concern is in the use of pesticides on farm-land and their movement, accumulation and concentration in the food chain. Although the pesticides used are bio-degradable (more so in the tropical and sub-tropical conditions prevailing in India), there is considerable evidence that certain pesticides belonging to the chlorinated hydro-carbon group are stable and tend to persist and accumulate in the soil. And although high concentrations of pesticides in the soil *per se* are not harmful, their subsequent take up by plants, birds, animals and man can progressively increase, their concentration in living tissue to dangerous levels. They can also be leached from farm-land into streams and rivers and thence enter man directly or through the aquatic food chain where they can accumulate in fishes. Seven people recently died in Jalgaon (Maharashtra) after consuming pesticide-polluted water from the river Tapti. The careful use of pesticides can reduce such risks considerably. In the present state of our agriculture and economic development it does not appear possible to do away with the organe-chlorine group of insecticides.

Although Indians are reported to have the highest concentration of DDT in body, in fact in the world, the indoor use of pesticides for the public health programme is considered to contribute very little to the problem of environmental pollution. WHO advocates the indoor use of even highly persistent pesticides like DDT. According to WHO, pollution of environment with DDT has been due to the out-door use of DDT in agriculture. It is yet to be estimated to what extent the use of pesticides in public health, veterinary practice and forestly contribute to the pesticide pollution.

3.3 *Research programmes* : The major thrust is to determine bio-degradability and residual toxicity under Indian conditions of the imported and indigenous pesticides in use. A new 'natural' insecticide is under investigation at BARC. This needs to be vigorously supported.

4. *Noise.*—Indian cities and industrial establishments are perhaps the noisiest in the world. It is now known that noise has a substantial detrimental effect on human performance. Sustained exposure to a noisy environment can result in creeping deafness which is detected too late, if at all. Research and Development programmes in this area are designed to survey noisy environments and to develop suitable technologies for noise abatement. A spin-off benefit is a facility that can be used to test high-performance wound equipment for sound studies.

5. *The outlays for the programmes are as follows* :

No.	Area	Outlay (Rs. lakhs)
5.1	Water Pollution	100
5.2	Air Pollution	100
5.3	Pesticides	50
5.4	Noise (includes nonrecurring national anechoic chamber facility—15 lakhs)	40
	TOTAL	290

Ecological and environmental training, education and research.

Ecology and environmental studies being new fields, the purpose of programmes in this area is to introduce and consolidate new curricula in these disciplines in schools and universities. The programmes are worth Rs. 115 lakhs.

Country contribution to UNESCO's Man and the Biosphere programmes.

1. *Introduction.*—The accelerating growth of population, increasing food requirement, rapid industrialisation, growing pollution and progressive depletion of natural resources are threatening the health and stability of the biosphere on which man depends for his life-support. Realising the importance of environmental problem, UNESCO has decided to launch a long-term inter-governmental and inter-disciplinary research programme on 'Man and the Biosphere' (MAB). The Government has accepted to participate in this programme and has entrusted the National Committee on Environmental Planning and Coordination (NCEPC) with the responsibility for its implementation. The NCEPC has constituted a multi-disciplinary MAB Research Committee specifically for developing this programme in the country. The NCST is including the research programmes identified by the NCEPC under MAB in the National Science & Technology Plan for completeness. The MAB programmes have been planned with the following objectives :

(a) research on the structure and functioning of the biosphere ;

(b) assessment of the extent to which the biosphere can be modified by man without impairing its functional structure ;

(c) study of the effect of the man-made environment on man himself ; and

(d) education related to these items.

So far, short-term objectives have prevailed in natural resources utilization, without much regard to the environmental aspects. The MAB programme is planned as a long-term activity to provide better understanding of the natural processes so as to increase man's ability to manage efficiently the natural resources of the biosphere. The programme envisages active cooperation of the member governments in organising the research activities within their country.

2. *Financial Requirements.*—The five Research Groups set up by the MAB Research Committee for different research projects under the Man and the Biosphere Programme have initially received 22 research proposals for inclusion in the MAB programme. The estimated total cost of these projects comes to Rs. 636 lakhs, of which Rs. 40 lakhs is accounted for by MAB research proposals which are included by the ICAR in its Plan proposals. The MAB research programme is envisaged as a long-term activity; hence new research proposals shall be regularly added in future incorporating new data and experience gained through MAB research projects and other related activities. Excluding the research proposals made to the ICAR, the total estimated expenditure on MAB programmes through the OEPC works out to be Rs. 607 lakhs, whose break-up is presented below :

Item	Rs. (lakhs)
(a) MAB research proposals tentatively scheduled to be executed through OEPC DST	592.0
(b) Symposia, Seminars, Workshops and other related training activities of MAB programme	10.0
(c) MAB Secretariat	5.0
Total	607.0

The significance and justification of MAB programmes are detailed in the Plan proposals of the Department of Science & Technology.

The outlays proposed by the various groups are as under:—

Sl. No.	Group	Area	Financial Outlay (Rs. lakhs)
1.	Environmental Aspects of Human Settlement	1.1 Settlement Planning and Management	175
		1.2 Land Use	65
		1.3 Transportation planning	45
		1.4 Water Supply & Sanitation	
		1.4-1 Water Supply	80
		1.4-2 Drainage and waste disposal	120
		Total :	485
2.	Environmental Aspects of National sources Management	2.1 Agriculture & Soil	100
		2.3 Forest	30
		2.3 Wildlife	30
		2.4 Mining & Metallurgical industries	40
		Total :	200
3.	Environmental Pollution . . .	3.1 Water Pollution	100
		3.2 Air Pollution	100
		3.3 Pesticides	50
		3.4 Noise	40
		Total :	290
4.	Ecological and environmental training, education & research		115
5.	Country contribution to UNESCO'S (MAB Programme) Man and the Biosphere Programme.		607
		GRAND TOTAL	1697

The various projects Proposed by the groups are as shown below : –

ject Index No.	Title of the project	financial outlay (Rs. lakhs)
1	2	3
	G_1 ENVIRONMENTAL ASPECTS OF HUMAN SETTLEMENT	
	A_1—Settlement Planning & Management	
$G_1A_1P_1$	Evolving environmental indicators and standards for urban and rural settlement.	15
2	Methods of comprehensive planning for human settlements, industrieal complexes incorporating environmental considerations.	20
3	Studies on slums and squatter settlements.	30
4	Establishment of criteria for developing environmentally satisfactory rural settlements.	40
5	Evolving environmental improvement plans for deteriorating parts of selected cities and towns.	10
6	Evolving suitable environmental regulatory measures for management of human settle ments.	10
7	Integrated surveys and studies into all aspects of environmental problems of metropolitan cities.	50
	Total G_1A_1	175
	A_2—Land use	
$G_1A_2P_1$	A comprehensive survey of land use pattern of selected cities and towns.	50
2	Comprehensive urban planning for optimization of horizontal and vertical development in relation to density patterns and environment requirements.	15
	Total G_1A_2	65
	A_3—Transportation planning	
$G_1A_3P_1$	Evolving planning for inter city transporation net-work to meet the growing needs of transportation of man and goods in selected areas.	20
2	Evolving efficient transportation management and operational mechanisms for big cities	25
	Total G_1A_3	45
	A_4—Water Supply	
$G_1A_4P_1$	Evolving improved methodology for designing water distribution network systems.	20
2	Developing suitable methodology for detecting and reducing loss of water in distribution systems.	10
3	Innovation/development of low cost water treatment processes (including processes of brackish water purification, removal of iron, manganese, etc.)	50
4	Recycling of water for industrial uses in certain industries like textiles, paper, petroleum, fertilizers, etc.	*
	Total G_1A_4	80

*Project No. $S_{18}G_1A_4P_4$ has been budgetted in panel 23 (recycling of waters)

1	2	3
	A5— Drainage and waste disposal.@	
$S_{18}G_1A_5P_1$	Development of improved methodology for sewerage design/management to suit different conditions.	
2	Studies on viability and methods of non-water carriage system of disposal of wastes.	
3	Process innovation/development and evolving ecologically balanced low cost waste disposal.	
4	Disposal of sewage effluents for land irrigation or by ground water recharge-optimality studies.	
5	Development of solid waste management models for optimisation of cost of collection, transportation and disposal.	
6	Evolving new technique (unconventional) for economic recycling disposal of solid waste.	
7	Water quality standards for sewage effluents used for different purposes (e. g. agriculture. fish culture and industry.	
	Total G_1 A_5 . .	
	G_2—Environmental aspects of Natural Researches management	
	A1—Agriculture & Soil.	
$S_{18}G_2A_1P_1$	Integrated post control including combination of regulated pesticide use and crop diversification.	
2	Systematic evaluation of various types of mulches primarily in the form of crop residues; engineering agronomic techniques for reducing wind-water erosion and promoting soil stability.	
3	Investigation into bio-geochemical cycling of nutrients in areas under intensive agriculture with special reference to essential micro-nutrients such as sulphur, zinc, iron, copper, etc.	
4	Evolving suitable methods of aquatic weed control.	
5	Conservation of important breeding grounds of fresh water fisheries in India.	
6	Long term impact of large scale irrigation on soil fertility under different agroclimatic conditions.	
7	Effect of pollutants on aquatic ecosystems with special regard to fish population. .	
	Total G_2A_1 . .	
	A2—Forests	
$S_{18}G_2A_2P_1$	Evaluation of transpirational loss of water from different tree species. . .	
2	A comparative study of natural forests with man-made forests (e.g. *Eucalyptus*) in terms of their flora, fauna, estimation of abundance, frequency of important wildlife species, diseases carrying arthropods and soil characteristics under different climatic regions.	
	Total G_2A_2 . .	
	A3—Wild Life	
$S_{18}G_2A_3P_1$	Studies on habitant requirements of important wildlife species.	
2	Studies to evaluate the impact of large scale construction, dams clearing and developing of land on wildlife species.	
3	Developing scientific methods for large scale crocodile farming.	
4	Census of water-fowl population in selected wetlands by aerial photographic method as well as conventional methods.	
	Total G_2A_3 . .	

@ Refer also to $S_{15}A_1$ G_5 on Public Health engineering, in Sector on urbanisation.

1	2	3
	A_4—Mining and Metallurgical Industry.*	
$G_2A_4P_1$	Studies of the impact of mining processing industries on the environment.	5
2	Development of suitable methods for reducing atmospheric pollution at mining and ore handling sites.	15
4	Evolving techniques for stablization and revegetation of spoil mounds ard abondoned quaries.	5
4	Environmental control in the iron and steel industry.	15
	TOTAL G_2A_4 . .	40
	G_3—*Environmental Pollution Control.*	
	A_1—Water Pollution.	
$G_3A_1P_1$	Studies of wastes assimilative capacity of streams and estuaries for water pollution control.	20
2	Bacterial contamination of water as related to large scale public health hazards.	15
3	Evolving methods for effective treatment of industrial effluents of some selective industries like Papr, fertilizer, chemicals, oils, etc.	15
4	To study the effect of work heat-waste aquatic ecosystem.	5
5	Development of water quality criteria for different uses and evolving water quality indices.	10
6	Assessment of coastal pollution with particular reference to oil and coal-tar. . .	15
7	To make objective assessment of problems affecting the marine environment and its biotic resources especially in coastal waters, big cities, industrial complexes, and harbours.	5
8	Study of survival multiplication and mode of dispersal of hepatitis virus (and to develop suitable vaccine.)	10
	TOTAL G_3 A_1 .	95
	A_2—Air Pollution	
$8G_3A_2P_1$	Survey and monitoring of air pollution in selected areas with special regards to nature and causes and variation of pollution during the year. Development of air-quality surveillance, analysis & monitoring equipment.	50
2	A design study for evolving specifications for and integrated monitoring system of air pollution in cities.	5
3	Evolving criteria and standards for affluent gases and air quality and developing air-quality indices.	10
4	Process and equipment innovation for air pollution abatement. (Precipitators, scrubbers, etc.)	20
5	Study of short-term and long-term effects of various air pollutants individually and in different combination on human health.	10
6	Development of fluid-dynamic models of air polluant dispersal.	5
	TOTAL G_3A_2	100
	A_3—Pesticides	
$8G_3A_3P_1$	Research on the estimation of pesticide residues in soils, plants, agricultural products and their effects in the environment.	20
2	Biodegradation of various pesticides under different environmental conditions.	5
3	To evaluate the potential and efficacy of Garlick oilseed insecticide.	15
4	Survey of DDT content in the human body fat.	5
5	Appraisal of the various prophylactic schedules of pesticide application recommended for plant protection.	5
	TOTAL G_3A_3 . . .	50

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*Refer to S_{23} G_2 Projects on Industrial Wastes also.

1	2	3
	A₄—Noise	
S18G3A4P1	Quantitative survey of noise levels in selected cities, industrial establishments, airport, etc.	
2	Development of cheap portable noise measuring instruments	
3	Development of noise insulation and noise-reducing mufflers, silencers etc. for industrial machinery.	
4	Setting up of instrumented anechoic chamber for sound and noise research.	
	TOTAL G3A4 .	
	G₄—Ecological Research, Training and Education	
S18G4P1	Revision of School curricula for introducing new material concerning environment and ecology with the object of forging an inter-disciplinary approach in the teaching human environment.	
2	Training for primary and secondary school teachers for teaching concepts of ecology and human environment.	
3	Courses on environment for the training of professionals such as doctors, engineers, architects, town and landscape, planners lawyers etc. during their normal teaching programmes.	
4	Evolving and conducting short-term courses for in service technical people, decision-makers etc.	
5	Centres for research and training in ecology and environmental sciences.	
6	Development of wild life educational tourism.	
	TOTAL G4 .	1
	G₅—MAB Research Proposals	
S18G5P1	Evaluation of ecological changes in the watersheds of river valley projects for identifying cases of rapid rate of salting in the reservoirs and evolving methods to control them.	50.
2	Study of ecological changes brought about by the changes in the pattern of land-use as a consequence of new settlements in forest areas	10.
3	Studies on forest ecosystems in different bioclimatic regions in systems context .	10.
4	Coordinated project on the impact of Human activities on the dynamics of arid and semi-arid zone ecosystem with particular reference to the effect of irrigation . .	110.
5	Control of water hyacinth *Eichhornia* cressipes (Mart) Solms and other equatic weeds	7.
6	Conservation research on the ecosystem of Chilka Lake in Orissa.	115.
7	Investigations on the Ganga, Jamuna and Cauvery river ecosystems to determine Biological Indicators of water quality.	4.
8	All India Coordinated project on the assessment of the effects of fertilizer use and pest Management on changing environments under intensive cropping.	40.
9	Problems of Indian Arid Zone Biome: Analysis structure and functions.	200.
10	Trials with exotic natural enemies for biological control of water hyacinth **(Eichhornia, crassipes)** and water fern **(Salvinia anuriculata)** in India	10.
11	Economics and related studies of natural disasters (Floods, cyclones etc.)	50.
12	Study of macro-impact of developmental projects	10.
13	Nature conservation society	5.
14	Effect of submerged vegetation the ecology and water quality of man-made reservoirs.	15.
15	Structure and functioning of dry deciduous forest ecosystems.	
16	Ecological survey and control of *Salvinia*.	
17	Eutrophication and conservation of certain lake ecosystems.	
18	Structure and functioning of the wetland ecosystem at Ghana Sancturary, Bharatpur, with particular reference to the management of its avian fauna.	
19	Study of biological characteristics of some indigenous economic plants, their collection and conservation.	
	TOTAL G5 .	636

SECTOR—AGRICULTURE

AGRICULTURE

(1) *Introduction*

The NCST Panel on Agriculture has not drawn its own Science and Technology Plan but has considered the plan programmes of the ICAR with a view to making appropriate recommendations.

The broad objectives motivating agricultural research as conceived in the ICAR plan are growth and stability of food production through a significant increase in the yield of crops per unit of area and time, scientific land and water use leading to crop-planning based on ecology-cum-economics, soil care and fertility, water management and improvement in the quality and yield of export crops.

A broad indication of the direction in which research wil be directed is given below :

(1) The precise research strategy and priorities vary from area to area (arid, humid, high altitude, irrigated). For the arid areas more work on grasses, horticultural plants and forestry species is contemplated. A major programme of research will relate to evolution of intensive production systems under the air inflated polythylene houses. For the semi-arid areas, the All India coordinated research project on dry farming which is already in progress will be further strengthened. Under this project, a technological package involving water harvesting through farm ponds, mulching, appropriate tillage, fertiliser application, crop substitution, varietal planning, plant protection and post-harvest technology are being developed for each area and tested and demonstrated. In addition, crop life saving research designed both to save a crop when it runs into aberrent weather and to develop alternative cropping strategies to effect mid-season corrections in cropping pattern will be intensive. For humid tropical areas, priority in research will be given to plantation crops, acidity and micronutrient deficiency, developing flood avoiding varieties of crops. In the high altitude areas, research effort will be primarily directed towards identification of suitable land use pattern particularly in the context of the local problems of soil erosion and shifting cultivation. For the irrigated areas, research programme will mainly focus on measures for increasing efficiency of water use through developing multiple and relay-cropping techniques.

(2) *Research Organisation*

(a) *Basic Research.*—Both mission oriented basic and speculative researches will be supported in Agricultural Universities and in ICAR institutes. The suggestion of the National/ Commission on Agriculture to create chairs of distinguished professorship for enabling gifted scientists to do basic research will be implemented.

(b) *Applied Research.*—Such research will be carried out through a National Grid of cooperative experiments under well-defined coordinated projects/programmes. The major aim would be to bring about inter-disciplinary and inter-institutional collaboration on problems of immediate relevance to agriculture, animal husbandry and fisheries.

(c) *Adaptive Research.*—This research will relate to the adaptation of new technology to the specific agricultural conditions prevailing in each village.

(d) *Operational Research.*—Operational research projects will be based on systems approach and will involve examining the benefits as well as possible adverse effects of new technology in their totality. It will require interaction between agricultural scientists on the one hand, and economists and sociologists on the other, right from the planning stage.

(e) *Approach to Research Organisation.*—Some priority areas requiring attention are the improvement of the yield potential of pulses and oil seeds, the introduction of disease and pest-resistance as well as the development of pest and disease surveillance systems in the major crops, development of inter-cropping or companion cropping systems, the production of medium lift pumps and efficient pre-and post-harvest agricultural implements, qualitative improvement of jute, cotton, tobacco, lac and wool, development of norms for the scientific exploitation of both demersal and pelagic fishery resources, standardisation of composite fishery culture techniques, etc. The coordinated projects already in operation are proposed to be reviewed and rationalised in the light of the following criteria recommended by the National Commission on Agriculture :

(i) the projects should envisage problem-oriented applied research of known knowledge under different broad agro-climatic conditions with marginal short-term basic research;

(ii) the problems to be studied should be of national importance and they may belong to a single discipline or may be multi-disciplinary;

(iii) the problems should be such as to warrant the concentration of efforts of a number of scientists on a single problem; and

(iv) the projects should aim at developing recommendations in the shortest time for increasing production.

(3) *Institutions.*—Apart from strengthening the existing Central Institutes of Agricultural Research, provision has been made for the establishment of a Central Institute of Cotton (in which the existing Cotton Technological Research Laboratory, Bombay will be merged) and an Agricultural Engineering and Post Harvesting Technology Institute.

(4) *International Cooperation.*—Increased efforts will be made towards international and bilateral cooperation in agricultural research. In addition to forging close links between the All-India Coordinated Dry Land Farming project and ICRISAT, it is proposed to further strengthen the bonds between our national research institutes in the areas of wheat and maize improvement, potato improvement, tapioca improvement and the use of agricultural and industrial wastes and by-products in animal production system, rice improvement, systems approach to animal production, etc.

(5) *Agricultural Education.*—The present educational facilities (73 agricultural colleges, 22 veterinary colleges, 2 dairy colleges and 8 agricultural engineering colleges) will sufficiently meet the agricultural manpower requirements of the Fifth Plan. Therefore, no expansion is proposed in the number of institutions concerned with agricultural education. The emphasis in the Fifth Plan will be on improvement of standard and quality of education, consolidation of postgraduate education, orientation of curiculla and courses to suit the changing needs of agricultural development, strengthening of inter-institutional collaboration and development of centres of excellence. The agricultural institutes will develop programmes involving work experience, practical training apprenticeship, etc. to inculcate confidence amongst the students and to make them not only more 'employable' but also capable of earning their living through self-employment. The Education Commission's recommendation to have at least one agricultural university for each State of India should be adhered to. A number of agricultural polytechnics proposed to be set up in the Fifth Plan period will provide in-service training to the extension staff of the Departments of Agriculture, Animal Husbandry and Fisheries and public/private sector corporations and impart technical skills to selected farmers. These polytechnics will be

un by either agricultural universities or ICAR institutions. It is also proposed to establish national staff college in agriculture which will provide courses for research and educational nanagement, short in-service and educational management, short in-service courses in project ormulation, B.Ed. course in agriculture, etc.

(6) *Extension Education.*—In the Fifth Plan, a proper restructuring and strengthening of nachinery for agricultural extension and administration is conceived as a task of primary imporance. Under this, the machinery will have to be upgraded at various levels—state, district, block and village. A feed-back relationship with the farmers and the field extension staff through mini-kit demonstrations, national demonstrations, agricultural polytechnics, operational research proects will be maintained.

(7) *Headquarters Strengthening.*—The programmes include strengthening of research information planning and coordination, Crop Science Wing, the technical wing of the Plant Protection Unit, Animal Science Wing, creation of a Manpower and Placement Cell and a University wing and Evaluation Cell, etc.

A brief description of the specific programmes in crop science development, plant protection, soil agronomy, etc. is given below :

(i) *Crop Science Development.*—The schemes for the improvement of wheat, rice, maize, ragi, jowar, sugarcane, sugar-beet, tobacco, soyabeen, pulses, oilseeds, groundnut, etc. started during the Fourth Plan, would be continued in the Fifth Plan to achieve high-yielding, high degree disease resisting, fair and tolerant varieties.

(ii) *Plant Protection.*—Forecasting of important diseases of selected crops and strengthening of existing coordinated crop projects from the pathological angle and integrated approach to the problem of pest control without much disturbance to the natural balance will be taken up. This new programme will include biological control of insect pests, rodents, termites, control of plant nematodes etc.

(iii) *Soil Agronomy, Water Management and Engineering.*—The projects will include, *inter alia*, water management and soil salinity, new cropping pattern, dry farming research, R & D at farm machinery and implements and production of prototypes, post-harvest technology, energy requirements in intensive agricultural production programmes, agrometeorology. It is proposed that the existing projects may be continued and some new ones will be started.

(iv) *Animal Science and Fisheries.*—The main objectives of projects/programmes would be to develop suitable type of strains of animals of high productivity so as to increase the edible animal products like milk, meat, fish, egg and commercial products like wool, hair and skin, determination of the economics of milk production under intensive dairy farming, designing and fabrication of dairy equipment, composite culture of Indian and exotic fishes, ecology and fisheries of fresh water reservoirs, riverine fish seed production, marine prawn biology, brakish water fish farming, utilisation of animal by-products, etc.

(8) *Financial Outlay.*—In the Fifth Plan, an overall public sector outlay of Rs. 7,300 crores is visualised for agriculture, irrigation and allied sectors. A statement indicating the tentative programme-wise break-up of the Fifth Plan outlays and also their comparative position in the Fourth Plan is enclosed (Annexure I). It will be noticed that agricultural research and education will involve an outlay of Rs. 200 crores, including Rs. 50 crores as the States and Union Territories' share. Annexure II gives a summary of the outlays required for various programmes and

Annexure III, shows detailed break-up of the outlays mentioned in Annexure II. The following points may kindly be noted :

(i) A provision of Rs. 100 lakhs each has been made for the Bureau of Plant Introduction and the two new Institutes on Cotton Research and Agricultural Engineering.

(ii) The All-India Coordinated Programmes are proposed to be financed from the Cess Funds.

(iii) A provision of Rs. 500 lakhs for Soil Survey and Land Use Planning has been separately included in the budget of the Union Department of Agriculture.

The detailed proposals on the basis of the allocations indicated above are being worked out by the respective ICAR Institutes, etc. Almost all the research programmes will be carried out in the agricultural institutions under ICAR.

Annexure-I

Programme-wise break-up of the Fourth and the Fifth (Tentative) Five-year Plans outlays on Agriculture and Allied Sectors

(Rs. in Crores)

Head of Development	Fourth Plan outlay				Fifth Plan outlay (Tentative)			
	States	Centrally Sponsored	Central	Total	States/ UTs.	Centrally sponsored	Central	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Agricultural Research and Education	—	—	85	85	50	—	150	200
2. Agril. Inputs, Extension, Training, Administration & crop-oriented production Programmes.	355	46	20	421	450	200	90	740
3. Minor Irrigation	508	—	8	516	750	10	30	790
4. Major & medium Irrigation	938	—	15	953	1900	35	65	2000
5. Flood control & drainage & Anti-sea erosion	125	—	8	133	175	—	115	290
6. Soil Conservation & Land Development	129	30	1	160	240	40	20	300
7. Command Area Development	22	—	16	38	50	—	100	150
8. Animal Husbandry & Dairying	118	5	110	233	470	55	175	700
9. Fisheries	49	6	28	83	90	20	50	160
10. Forestry	87	1	4	92	160	10	30	200
11. Cooperation	124	25	30	179	260	50	100	410
12. Community Development & Panchayati Raj	98	12	6	116	100	—	10	110
13. Agril. Credit	—	—	324	324	100	—	290	390
14. Agril. Marketing					10	—	20	30
15. Storage & warehousing	7	—	87	94	20	—	120	140
16. Agril. Processing	—	2	16	18	—	—	40	40
17. Buffer Stocks of Agril. Commodities	—	—	255	255	—	—	100	100
18. Special Projects & Programmes of Rural Development & Employment	—	—	115	115	100	—	400	500
19. Land Reforms	—	—	—	—	25	—	25	50
TOTAL	2560	127	1128	3815	4950	420	1930	7300

Summary of outlays required for various programmes

Annexure-II

	Proposed Outlay (Rs. in lakhs)
A. Agricultural Sciences	
Coordinated Projects	
Food Crops	762.00
Commercial Crops	478.50
Horticultural Crops	313.50
Soil, Agronomy, Water Management & Agricultural Engineering	1504.00
	3058.00
Centrally administered areas	180.00
New Institutes (including Plant Introduction Bureau)	300.00
I.C.A.R. Instts. (Agri.)	2872.00
H.Q. Schemes	200.00
Agri. Education	4800.00
TOTAL (A)	11410.00
B. Animal Sciences	
Animal Sciences Institutes	1944.00
Animal Science Co-ordinated Projects	1346.00
Statistics Institute	300.00
TOTAL (B)	3590.00
GRAND TOTAL (A&B)	15000.00
C. Coordinated Programmes	
Agricultural Sciences	173.00
Animal Sciences	103.00
Statistics	75.00
TOTAL (C)	351.00*
D. Soil Survey and Land Use Planning	@
GRAND TOTAL	15,000.00

*To be met from Cess Fund.

@Included in the budget of Department of Agriculture.

Annexure III

FINANCIAL STATEMENT OF V PLAN PROPOSALS

ITEM	Proposed outlay (Rs. lakhs)		
	I.C.A.R.	State	Total
1	2	3	4
A. Coordinated projects			
Food Crops			
1. Rice	120.00	40.00	160.00
2. Wheat	96.00	26.00	122.00
3. Barley	22.50	7.50	30.00
4. Maize	82.00	27.00	109.00
5. Sorghum	95.00	27.00	122.00
6. Millets	40.00	13.00	53.00
7. Pulses	280.00	93.00	373.00
8. Forage Crops	26.50	8.50	35.00
TOTAL	762.00	242.00	1004.00
Commercial Crops			
1. Sugarcane	45.00	15.00	60.00
2. Sugarbeet	27.00	8.00	35.00
3. Cotton	135.00	45.00	180.00
4. Jute	36.00	12.00	48.00
5. Oilseeds	180.00	60.00	240.00
6. Soyabeen	21.50	7.50	29.00
7. Tobacco	34.00	11.00	45.00
TOTAL	478.50	158.50	637.00
Horticultural Crops			
1. Fruits	117.00	39.00	156.00
2. Tuber Crops	18.00	6.00	24.00
3. Potato	30.00	10.00	40.00
4. Vegetables	45.00	15.00	60.00
5. Medicinal and aromatic plants	19.00	6.00	25.00
6. Horticulture	20.00	3.00	23.00
7. Spices and cashewnut	33.00	11.00	44.00
8. Coconut and arecanut	31.50	10.50	42.00
TOTAL	313.50	100.50	414.00
Soils, Agronomy, Water management and Agricultural Engineering			
1. Water Management Schemes :			
(*a*) Water Management and soil salinity	90.00	30.00	120.00
(*b*) New Cropping patterns	42.00	14.00	56.00
(*c*) Use of saline water	33.00	7.00	40.00
(*d*) Water management in higher rainfall and temperate hill zones	48.00	10.00	58.00
2. Production Research :			
(*a*) Correlation of soil test with crop response	38.00	12.00	50.00
(*b*) Micronutrient research	63.00	7.00	70.00
(*c*) Measurement, evaluation and improvement of soil structure	34.00	11.00	45.00
(*d*) Microbial decomposition and recycling of urban and rural wastes	17.00	5.00	22.00
3. Dry Farming Research	205.00	45.00	250.00
4. All India Coord. Project on Agronomic Research	300.00	100.00	400.00

1	2	3	4	5
5.	Operational Research (including National Demonstration and integrated Pest Control Projects)	440.00	90.00	530.00
6.	Research and development of farm machinery and implements and production of prototypes and their evaluation	57.00	15.00	72.00
7.	Optimisation of ground water utilisation through open wells and pumps	18.00	6.00	24.00
8.	Post harvest technology	32.00	10.00	42.00
9.	Energy requirements in intensive agricultural production programmes	23.00	7.00	30.00
10.	Technological aspects of major and minor oil cakes and agri. wastes	18.00	6.00	24.00
11.	Agricultural Meteorology.	45.00	15.00	60.00
	TOTAL	1503.00	390.00	1893.00
B.	**Animal Science and Fisheries.**			
		(Rs. in lakhs)		
1.	Cattle Breeding	369.00	123.00	492.00
2.	Buffalo breeding	149.25	49.75	199.00
3.	Sheep breeding	158.92	51.98	210.90
4.	Poultry breeding	265.00	85.00	350.00
5.	Goat breeding	79.50	26.50	106.00
6.	Pigs	64.50	21.50	86.00
7.	Mineral imbalance	45.00	15.30	60.30
8.	Agril. by-products & Industrial waste materials	64.00	21.80	85.80
9.	Specialised dairy farming	29.65	8.33	37.98
10.	Foot & mouth disease	57.50	19.50	77.00
11.	Composite culture of Indian & exotic fishes	5.00	1.66	6.66
12.	Propagation of air breathing fishes in swamps	4.47	1.50	5.97
13.	Ecology & fisheries of fresh water reservoirs	8.22	2.74	10.96
14.	Riverine fish seed production	6.40	2.15	8.55
15.	Marine prawn biology	1.63	0.54	2.17
16.	Utilisation of trash fish	19.44	6.48	25.92
17.	Transportation of fresh fish	3.60	—	3.60
18.	Brackish water fish farming	13.90	4.64	18.54
		1344.98	442.37	1787.35
B.	**Programmes :**			
1.	Technological & económic problems in milk plants	13.50	4.50	18.00
2.	Indigenous milk products	22.50	1.50	24.00
3.	Utilisation of animal by-products	25.00	—	25.00
4.	Canary colouration of Indian wools	18.00	2.00	20.00
5.	Manufacturing trials of Indian wools	24.00	—	24.00
		103.00	8.00	111.00

1	2	3	4	5
	ALL INDIA COORDINATED PROGRAMMES			
Horticultural Crops :				
	1. Mushroom Cultivation	12.00	3.00	15.00
	2. Post Harvest technology of Hort. Crops	11.50	3.50	15.00
		23.50	6.50	30.00
Plant Protection				
	1. Forecasting of important diseases and pests	1.50	0.50	2.00
	2. Biological control of insect pests	9.00	1.00	10.00
	3. Coordinated Programme on rodents	5.00	1.00	6.00
	4. Coordinated Programme on termites	—	—	—
	5. Nematode advisory Laboratory & control	21.00	7.00	28.00
	TOTAL	36.50	9.50	46.00
Agronomy and Water Management				
	1. Assessment & effect of management of pests and of fertiliser use on changing environment under intensive cropping	30.00	10.00	40.00
	2. Collective management technology for small farmers	20.00	—	20.00
	3. Weed Control	27.00	9.00	36.00
	4. Water yield studies in selected catchment areas	36.00	—	36.00
	TOTAL	113.00	19.00	132.00
Statistics				
	1. Developing measurement technique & estimation methodology relating to crops	12.93	4.31	17.24
	2. Developing statistical methodology in Animal Husbandry	13.83	4.61	18.44
	3. Sample Survey Methodology	18.20	6.07	24.27
	4. Sample Survey Methodology High Yielding varieties Programmes	30.06	10.02	40.08
	TOTAL	75.02	25.01	100.03

I.C.A.R. INSTITUTES

Institutes (Agriculture)	(Rs. in lakhs) Financial Allocations
I.A.R.I.	900.00
C.R.R.I.	305.00
C.P.R.I.	130.00
Breeders Seed Stock	75.00
J.A.R.I.	50.00
C.T.R.I.	50.00
New site & Buildings	60.00
C.T.R.I.	60.00
I.G.F.R.I.	175.00
I.I.H.R.	200.00
J.T.R.L.	40.00
I.L.R.I.	35.00
C.T.R.L.	90.00
C.A.Z.R.I.	100.00
S.&W.C. Centres	100.00
C.S.S.R.I.	180.00
I.I.S.R.	70.00
S.B.I.	50.00
C.P.C.R.I.	80.00
Spices Regional Station	42.00
Pl. Virus	80.00
TOTAL	2872.00

Animal Sciences Institutes

1. Indian Vety. Research Institute	740.00
2. National Dairy Research Institute	399.00
3. Central Sheep & Wool Research Institute	220.00
4. Central Inland Fisheries Research Institute	150.00
5. Central Marine Fisheries Research Institute	260.00
6. Central Institute of Fisheries Technology	175.00
TOTAL	1944.00

ATOMIC ENERGY

ATOMIC ENERGY

Nuclear energy is an area of technology in which the gestation time for getting a return on R&D is long. The large investments made on R&D over the past 20 years have now started paying dividends. The primary orientation on R&D programmes continue to be directed towards power generation using natural uranium heavy water reactors initially, and fast breeder reactors subsequently. This strategy would enable utilisation of country's extensive thorium resources. The lead time available now is planned to be fully exploited to generate technological competence through indigenous R&D. The R&D efforts in the Department of Atomic Energy will mainly be organised at BARC, TIFR and AMD.

The major areas of R&D during the V Plan are the construction of a 100 MW thermal research reactor at Trombay and the development of the Reactor Research Centre at Kalpakkam. The 100 MW reactor is meant for testing prototype fuel elements, material testing programmes and production of radio isotopes of higher specific activities. The Reactor Research Centre is being developed for fast reactor technology and would include a 15 MW fast reactor, radio metallurgical, radio chemical and materials laboratories, pulsed fast reactor, etc. The above two on-going projects account for about 70 per cent of the proposed outlay on R&D. Out of the remaining, many of the schemes pertain to existing facilities such as modifications to existing research reactors, health and safety labs., etc. New work proposed to be undertaken includes radio pharmaceuticals, radiation sterilisation plutonium and uranium plant expansions, cobalt handling facilities, fuel fabrication for fast reactors, reliability evaluation lab. etc.

The total financial outlay for R&D sector of the Fifth five year plan of the Department of Atomic Energy amounts to about Rs. 157 crores.

India is one of the few countries in the developing world which has established sound nuclear know-how and has already been classified by the IAEF as the 9th most developed country in the world in the peaceful uses of atomic energy. The proposed Atomic Energy R&D programme in the V Plan will enable the country to keep abreast of developments in this field in other developed countries. There are immense prospects of extending assistance to other developing Afro-Asian countries (already considerable progress has been made with several South-East Asian countries) and improved our international image considerably.

SPACE

DEPARTMENT OF SPACE

The subject of space research was initially allocated to the Department of Atomic Energy by the Government of India in August, 1961. By a resolution, on June 1, 1972, the Government of India established a Space Commission on the analogy of the Atomic Energy Commission. The objectives of the Space Programme have been brought out in the profile for the decade 1970-80 of Atomic Energy and Space Research formulated by the Department of Atomic Energy, which states thus :—

> "The principal objectives of the Space Programme in India are to develop indigenous competence for designing and building sophisticated hardware involved in space technology including rockets and satellites for scientific research and practical applications, the use of these systems for providing point-to-point communication and a National Television hook-up through a direct broadcast synchronous satellite, and the applications of satellites for meteorology and for remote sensing of earth resources."

The programme and activities of the Department of Space can be divided Subject-wise into three broad areas of (1) Space Sciences (2) Space Technology and (3) Space Applications. Space sciences include research programmes in aeronomy, X-ray and gamma ray astronomy, plasma physics, cosmic rays, studies of lunar material, meteorites etc. Space Technology covers all aspects of work related to the development of rockets, satellites, propellants, scientific payloads and ground and space instrumentation. Space applications represent the translation of the knowledge gained in space research and technology into practical applications in the field of satellite communication, satellite-television, meteorology, geodesy, navigation and earth resources survey.

The physical targets proposed to be achieved in the Fifth Plan by the Department of Space are given below:—

(i) Satellite launching capability :

   (a) further development of sounding rockets;

   (b) the development of satellite launching vehicles for launching of satellites of varying sizes and complexities.

(ii) The development of scientific and technological satellites and of synchronous satellites.

(iii) The establishment of facilities for the production of rockets and propellants;

(iv) The development of test facilities;

(v) The completion of the Satellite Instructional Television Experiment;

(vi) The establishment of a national satellite for television and tele-communication and the software required;

(vii) The development of capability within the country for various other applications using satellites including remote sensing; meteorology; geodesy and navigation;

(viii) The establishment of facilities required for these activities such as laboratorie buildings, computational facilities and control management activities.

(ix) The development of the Physical Research Laboratory as a national centre space sciences.

(x) Manpower development including research projects, training etc. with special emphas on the utilisation of institutions of higher learning throughout the country. An effor will also be made to establish concrete interface with industry in India to undertak many specific tasks connected with the space programmes.

4. The Department of Space has proposed an outlay of Rs. 141.22 crores for the R&D programmes of the Deparament. The broad details of the programmes are given below.

DEPARTMENT OF SPACE (FIFTH PLAN OUTLAY)

	(Rs. in Crores
1. Development of Rocket Technology and Satellite launch capability.	50.36
2. Satellite Development.	15.00
3. Research and Development work on Space applications.	24.00
4. Lunch. Test, production and common facilities at Sriharikota.	36.86
5. New Rocket and Satellite Technology Centre.	5.00
6. Computational facilities.	4.00
7. Research Projects, training and manpower development.	4.00
8. Physical Research Laboratory.	2.00
9. Central Management. .	1.00
TOTAL:—	141.22

In addition, there is a provision of Rs. 56 crores for the INSAT-I programme consistin of Rs. 50 crores for launching and fabrication of a satellite from abroad and a spillover provisio of Rs. 6 crores for the Satellite Instructional Television Experiment (SITE). The Deptt. of Spac anticipates a revenue of Rs. 20 crores from the use of the satellite during the Vth Plan. In th Planning Commission, this investment has been recommended under the Transport sector a INSAT-I would be primarily a user facility which would meet the operational requirement fo TV and some aspects of the remote sensing programme for meteorology (in a limited way) apar from providing thousand two way channel for telecommunications. It is understood that most o the programmes identified by the NCST has been included in the proposals of the Deptt. of Space

ELECTRONICS

ELECTRONICS

1. *Introduction*

**Electronics plays a very important role in the development of modern technology, in the monitoring and control production and industrial processes. Electronics is not very capital intensive and as such with a moderate initial capital, it is possible to generate capital faster than in most other industries. It is a labour intensive industry and has therefore potential for increased employment opportunities. Considering the dynamic character of electronics, its pervasive nature and its significant impact on science, industry and society, the Government of India in Feb., 1971 set up the Electronics Commission, entrusting the responsibility of ensuring the necessary balanced development of electronics on sound technical and economic principles in the shortest possible time and in the best possible manner. In order to facilitate regular exchange of ideas and mutually beneficial interaction among all the concerned agencies in Government and outside Government, the Electronics Commission has decided to set up a National Advisory Committee on Electronics (NACE). The research and development efforts in the field of electronics are mainly confined to the Government Agencies, namely, Defence, DAE, CSIR, Communication and Indian Telephone Industries. The present expenditure on research and development is estimated at about Rs. 4 crores per annum. The Planning Commission Task Force on Electronics and Telecommunication has estimated that the total requirement of electronics and tele-communication equipment and components during the Fifth Five Year Plan period would be about Rs. 3.000 crores. To achieve this target of production, an investment of about Rs. 485 crores. (Foreign Exchange Component Rs. 135 crores) would be needed. The Task Force considered the areas of Consumer Electronics, Mass Communication, Tele-Communication, Aerospace Electronics and Communication, Radar and Defence systems, Computer Control and Industrial Electronics and Instruments and Instrumentation. On the basis of total requirements of production of electronics equipments, the corresponding requirement of electronic components and materials during the plan period was also assessed. Keeping this in view the Electronics Commission has suggested an outlay to the tune of Rs. [illegible] crores towards R&D expenditure in these areas. Salient features of R&D effort are described in the following paragraphs:

2 *Consumer Electronics.*

Major items of Consumer Electronics such as Radio and TV Receivers, Tape Recorder, etc. are now being manufactured in the country mostly with indigenous know-how. However, since there are many products like TV receivers, tape recorders in which imported components are being used. R&D efforts are necessary to completely indigenize these products. Attempts should be made to develop items like stereo tape recorder, colour TV receivers, F.M. radio receivers, electronic toys and kits, video record players and tape-recorders etc. for the purpose of exports.

3 *Mass Communication.*

Most of R&D work in this field of mass communication are now being carried out by M/s. Bharat Electronics and All India Radio. Know-hows for the manufacture of many sound broadcasting and TV transmitters are already developed in the country. Further R&D efforts are needed for the development of super power medium wave transmitter, high power SW transmitter, TV translators, low power TV transmitter etc. Studies on software items like propagation and field strength characteristics of various types of transmission need to be intensified.

4. *Computers and Control System.*

Major input to the development of computers and peripheral equipment are systems design, development of CPU's and memories and slow speed peripheral like teleprinter, paper tape, input/output equipments. Although items like teletypewriters, paper tape readers, paper tape punch etc. are now being manufactured in the country, further R&D efforts are necessary to develop line printers, magnetic tape, card readers, gyros, etc. Intensive R&D efforts are also necessary to develop complex peripherals like high speed magnetic tape, cassette and disc drivers etc.

5. *Instruments and Instrumentation.*

The Task Force has suggested that the total requirement of electronic instruments as compared to total electronic equipment production in the country should be of the order of 8 to 9 per cent by the end of 1978-79. Target of production there should be an annual growth of 20 per cent (excluding process control instruments). Adequate R&D base for the development of these instruments exists in the country. In order to develop the sophisticated instruments the concept of adaptive research has been advocated on one-time purchase basis to reduce the foreign exchange drain. Also areas have been identified where it may be desirable to go in for pure research to update our knowledge with rapidly changing technology.

6. *Communication and Navigation*

Many items of communication systems, microwave components, navigational and signalling equipments, radar and sonar are presently manufactured in the country. Adequate R&D base exists in the country to take up further developmental work in sophistication of our telecommunication and navigational equipments. On the basis of present status of technology and future requirement of telecommunication and navigation equipment, necessary R&D effort has been suggested in the field of line communication, cables and wires, transmission equipment, electromechanical switching, digital communication, microwave communication system, navigational equipment, radar and sonar etc.

7. *Components and Materials.*

Adequate R&D base exists in the country in various national laboratories, IITs, and public sector enterprises for the development of electronic tubes, semi-conductor devices and other discrete and integrated circuits etc. Intensive R&D efforts are needed towards development of integrated circuits, high voltage R. F. Transistors, avalanche diodes, accoustic wave amplifier etc. Efforts are also needed for developing thick and thin film technology. As regards materials, research efforts should be concentrated on metals and alloys, ultra pure materials, chemicals and plastic. In the field of electronic and magnetic ceramic material, intensive R&D effort will be necessary for development of transparent, high purity fused quartz as well as substitute for quartz.

8. *R&D Investment*

The total requirement of electronic and tele-communication equipment during the fifth plan period has been estimated at Rs. 3,000 crores. To achieve this target of production, investment of about Rs. 350 crores has been envisaged. It has been suggested that an amount of Rs. 88 crores with a foreign exchange component of Rs. 41 crores would be necessary for R&D support. It is expected that this will generate an employment potential of 12,000 scientist, engineers and technicians. Detailed break up of R&D expenditure is given in Annexure I.

Annexure I

R & D PLAN IN ELECTRONICS AND TELECOMMUNICATION

(All Cost figures in Rs. Crores)

No.	Description	Consumer Electronics	Mass Communication	Computers and controls	Control System & Industrial Electronics	Instruments & Instrumentation	Telecommunication	Aero space Electronics	Radar and Defence-Systems	Components	Materials	Total
1.	Investment on Capital equipments (FE)	2.5	2.5	3.5	3.0	2.0	11.0	1.0	8.0	4.5	3.0	41.0
2.	Investment on Capital Equipments (Rs.)	1.0	1.0	2.5	4.1	0.7	11.0	0.8	5.4	5.5	4.0	36.0
3.	Investment on Civil works etc. (Rs.)	0.5	0.5	1.0	0.9	0.3	3.0	0.2	1.6	2.0	1.0	11.0
4.	Total Investment in FE	2.5	2.5	3.5	3.0	2.0	11.0	1.0	8.0	4.5	3.0	41.0
5.	Total investment in (Rs.)	1.5	1.5	3.5	5.0	1.0	14.0	1.0	7.0	7.5	5.0	47.0
6.	Grand Total Investment	4.0	4.0	7.0	8.0	3.0	25.0	2.0	15.0	12.0	8.0	88.0
7.	Total employment	700	500	900	1000	600	3500	300	2000	1500	1000	12000

C.S.I.R.

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

(C.S.I.R.)

In formulation of the programmes for the Fifth Five Year Plan, the CSIR has given emphasis on the following aspects :—

Promotion of R&D to meet the basic needs; higher productivity through R&D efforts; matching competence in devices, instruments, etc. to the chartered responsibilities of the Laboratories/Institutes; lowering cost of manufacture; developing technology for minimising imports and exploitation to the fullest extent of the export potential; search for special metals and materials; development of special materials; testing and analytical services; concentrating on industrial problems relating to specific regions; and utilizing old and existing techniques and providing activities to improve production in villages using local resources.

The programmes aim at generating employment opportunities for increased number of scientists and technologists in the industry by exploitation of know-how developed and in the Research and Development institutes. Employment of more scientists and technologists will result in greater number of indigenous processes, new products, turn-key jobs, improvements on know-how purchased, creation of a cadre of consultants, experts etc.

As regards social needs, the programmes are envisaged to cover the fields of housing, school buildings, all-weather rural roads, sanitation, pollution hazards, development of mineral and ground water resources etc. It is also proposed to establish several centres and new institutions in different backward regions. This will meet the technological needs of the regions concerned and will bring them to the level of developed areas. In order to bring in more close link between the laboratories and the industries, it is proposed to strengthen the industrial, technological and scientific information service, and undertake industrial surveys, marketing, economic evaluation, and promotion of sale of Research and Development.

Some of the programmes to be launched which would go a long way towards achieving self-reliance from a long term point of view are: production of oil from coal; process for nickel extraction; copper refining; production of sponge iron; optical glass production by continuous process; production of electronic materials, viz., silicon crystals, professional ferrites, high purity alumina, phosphorous, quartz crystals, etc.; semi-conductor devices and integrated circuits; medical and optical instruments; production of various grades of refractories; production of electrodes for batteries; production of materials for aluminium industry, e.g. soderberg paste, aluminium fluoride, cryolite, etc., alternative power sources, e.g. solar, wind and geothermal energy; organic intermediates for drugs and polymer industries; electronic devices and chemicals for defence uses; high-strength material composites (e.g. glass-fibres, plastics composite, etc.); leather goods and garments; utilisation of slaughter house wastes; development of airborne geo-physical survey facilities; ground water surveys and management etc.

A number of new institutes have been proposed. These fall under two categories; (a) those directly under the aegis of the different Laboratories, and (b) new Research Institutes to cater directly to the needs of the industry. Among category (a), some of the major Institutes proposed are: Field Station for Radio Science, Materials Science and Technology Research Centre, Regional Computer Centre at Bangalore, Centre for Advanced Research for Cellular

Biology, Regional Research Centres of National Geophysical Research Institute, Chemical Engineering Research Centre, etc. The Research Institutions proposed under category (b) have been proposed, taking into consideration the need of industrial development. These Institutions are expected to cater directly to the needs of industries and other sectors of economy. Further, these Institutions would work as National Centres which would coordinate the work done in the field in different parts of the country. A few examples of such Institutions are Welding Research Institute, Central Research Institute for Pulp and Paper Technology, Aluminium Institute of India, Solar Energy Research Institute, etc.

A total outlay of Rs. 187.85 crores has been proposed for the Fifth Five Year Plan. Its break-up under different broad Heads is shown below:—

Head	*Outlay proposed* (Rs. in crores)
I. National Laboratories.	
(i) New and continuing R&D Projects	71.15
(ii) Institutional Projects proposed by the Laboratories	51.85
(iii) Computer facilities	5.25
II. Central Administration	0.90
III. Centrally Administrated Heads	38.70
IV. New Research Institutes and Institutional type of activities.	20.00
Total	187.85

The projects identified by the various NCST panels to be implemented by the CSIR laboratories add up to Rs. 91.58 crores. Most of these programmes have been included in the CSIR's proposals.

PLANS OF OTHER MINISTRIES

PLANS OF OTHER MINISTRIES

In drawing up S & T Plan, the NCST had adopted a sectoral approach. The planning groups under each sector considered the programmes and proposals received from various specialists and institutions. In addition to this exercise, NCST had also invited S&T proposals from different ministries and most of the proposals received from Ministries have been taken into account in the sectoral reports presented in the draft plan.

However, there are some which have not been covered by the NCST panels and details of the same are presented in this chapter. These programmes relate to:

1. Ministry of Tourism and Civil Aviation which has submitted the programmes for their Research and Development Directorate.
2. Ministry of Information & Broadcasting which has submitted programmes of All India Radio.
3. Ministry of Petroleum and Chemicals which has submitted the programmes for Engineers India Limited and R&D Centre for Indian Oil Corporation.

The total requirement of funds for these programmes submitted by the Ministries amount to Rs. 8.84 crores. A summary of these proposals is given below:—

Sl. No.	Ministry/Department	Organisation		Outlay (Rs. lakhs)
1	2	3		4
1.	Tourism & Civil Aviation	Research and Development Directorate		80.00
2.	Information & Broadcasting	All India Radio		197.69
3.	Petroleum & Chemicals	(i) Engineers India Ltd.	250.65	606.65
		(ii) Indian Oil Corporation	356.00	
		TOTAL		884.34

Details of the various programmes are given in the following pages.

(1) *R & D Programmes of the Research and Development Directorate of the Department of Civil Aviation.*

In order to keep pace with modern developments in aeronautical sciences and engineering, to handle mathematical and engineering problems which arise day to day in the supervision of airworthiness, and at the same time to maintain a forward view to assist in guiding India's advance from the purely operational stage to the design and production stage, the Research and Development unit of the Department of Civil Aviation has been carrying out research on the following areas.

(a) Design and Development of Revathi trainer, light aircraft and gliders.

(b) Design and Development of glider launching winches.

(c) Development-testing of aeronautical materials and components.

(d) Development-testing of aviation fuels.

(e) Studies of and measurements of aircraft noise.

(f) Investigation of fatigue properties of light alloy materials used in the construction of aircraft.

The Department has already achieved a considerable self-sufficiency in materials for gliders and aircrafts such as aircrafts plywood, glue, fuels, fabric, safety belts, furnishing materials etc. They have also designed and developed gliders and winches which have been utilised for the production of their prototypes. The Department has testing facilities for development and testing of materials and components for aircrafts and aviation fuels to aircraft specification. Equipment for fatigue testing and noise/vibration testing, metallurgical microscope, ultrasonic X-ray equipment for investigating of failure of components are available with the Department. Thus nucleus of equipment and staff for R & D work exists in the Centre.

The department has suggested to undertake R & D work on various aspects involving aircraft operation. The total financial outlay required by the organisation is about Rs. 80 lakhs during the Fifth Five Year Plan period.

(2) *R&D Proposals of the Research Department of the ALL INDIA RADIO.*

The Research Department of the All India Radio has been investigating problems having a direct bearing on the technical operation, maintenance and improvement of the broadcasting service as a whole. The Department has established independent R & D Cells to deal with (a) ionospheric and propagation studies and their applications in net work planning; (b) acoustic properties of materials, studio design, performance of transducers like microphones, loudspeakers etc.; (c) problems relating to transmitters, aerials and receivers. In addition, they have a separate Research and Development Division which has been engaged in developing (a) crystal controlled solid-state master clock; (b) solid state distortion and noise level meter, (c) digital time display, (d) VHF Power amplifier for Channel VIII Band III T.V., (e) high gain Band III TV antenna, etc.

Their proto-type section is in the process of developing a large number of units such as solid-state 12" TV receiver, 19" hybrid TV receiver, Multichannel TV turner, video and pulse distribution amplifiers, solid-state TV translator, crystal controlled master close digital time display, F.M. transmitters, F.M. receivers, peak clipper etc.

The total financial outlay suggested by the Deptt. is about Rs. 198 lakhs. The details of the various programmes are as given below :—

1. Studio techniques for stereophonic broadcasts.
2. Study of interference to T.V. services in the V.H.F. band due to sporadic E.
3. Study of possible interference due to tropo-scatter in the V.H.F./U.H.F. bands.
4. Survey of noise fields in V.H.F./U.H.F. bands.
5. Study of ionospheric oblique propagation.
6. Scale model measurements in R. F. Anechoic chamber.
7. Study of Colour T.V. system for adoption in A.I.R.
8. Development of digital circuits for remote control and automation.

9. Development of T.V. translators of higher powers.
10. Development of band III T.V. transmitter.
11. Development of T.V. studio equipment.
12. Development of stereo F.M. receiver.

Projects under the Ministry of Petroleum and Chemicals.

A Group known as 'Petroleum Process Development Group' was formed in NRDC to bring about close co-ordination between the research laboratories, industry, design and engineering organisation and the NRDC for developing indigenous know-how for process of interest to the petroleum industry. This Group has identified a number of projects under (i) Petro-chemicals-distillation technology, extraction technology, extractive distillation, liquid phase oxidation of hydro-carbons and steam cracking and (ii) Petroleum Refining-visbreaking, dewaxing and deoiling, hydrogen processing of petroleum fractions and sulphur recovery. The total cost of the projects is Rs. 341.50 lakhs. The projects are to be implemented by the Engineers India Ltd. in association with NRDC, Indian Petrochemicals Corporation, Indian Oil Corporation and Indian Institute of Petroleum. It is envisaged that of the total cost of Rs. 341.50 lakhs, Rs. 65.85 lakhs would come from the NRDC; the balance of Rs. 270.65 lakhs would be provided by Engineers India Ltd.

The Indian Oil Corporation has proposed an outlay of Rs. 356 lakhs for an R & D Centre. It is proposed to carry out research on process development, refinery, pipeline corrosion problems and pollution preservation etc.

APPENDIX I

NCST PANELS AND PLANNING GROUPS

Name of the Panel	Planning Group
1. FAMILY WELFARE & HEALTH	1. Task Force on Nutrition.
	2. Clinical Trials of Drugs.
	3. NCST Group on Primate Research.
	4. Communicable Diseases.
2. NATURAL RESOURCES	1. Forest, Land, Soil and Wild Life
	(i) Plant Introduction, Silviculture and Management.
	(ii) Plant Breeding, Physiology and Ecology.
	(iii) Protection from pests and diseases.
	(iv) Farm Forestry and Range Management.
	(v) Wood Sciences.
	(vi) Pulp and Paper Products.
	(vii) Minor Forest Product (medicinal plants, essential oils etc.).
	(viii) Harvesting and Extraction.
	(ix) Land Use.
	(x) Watershed Management and Flood Control.
	(xi) Soil and Soil Plant Relationships.
	(xii) Wild Life and environmental conservation.
	2. Oil and Natural Gas
	(i) Origin, Migration and Accumulation of Petroleum.
	(ii) Biostratigraphy.
	(iii) Sedimentary Processes and Formation of Deltas.
	(iv) Exploration Geophysics including Well logging.
	(v) Drilling Techniques and Processes.
	(vi) Drilling Mud and Cement.
	(vii) Production, Reservoir Studies and Transportation.
	3. Geodetic and Topographical Surveys.
	(i) Aerial Photo-interpretation.
	(ii) Cadastral Survey.
	(iii) Photogrammetry.
	(iv) Surveying & Cartography.
	(v) Urban Land-use and Engineering Surveys.
	(vi) Printing Technology.
	(vii) Geodesy.

4. Mineral Resources.

    (i) Atomic Minerals.

    (ii) Ferrous Minerals.

    (iii) Non-Ferrous Minerals.

    (iv) Industrial Minerals.

    (v) Coal and Lignite.

    (vi) Geophysical Exploration.

    (vii) Remote Sensing.

    (viii) Structure & Tectonics of Mineralised Zones.

    (ix) Geochemistry & Petrology.

    (x) Gaps Between Exploration and Exploitation.

    (xi) Economic Geology.

    (xii) Data Processing.

    (xiii) Frontiers in Earth Sciences.

5. Water Resources.

5. A. Surface Water

    (a) Assessment Sub-sector

        (i) Precipitation, Snow and Glacier Study.

        (ii) Evapo-transpiration, Runoff, Recharge and Floods.

        (iii) Sediment and Water Quality Observation.

        (iv) Acquifer Indentification and subsurface Water Level Logging.

        (v) Hydrometry.

        (vi) Computerisation, Mathematical Modelling and Simulation.

        (vii) Satellite & Remote Sensors.

        (viii) Instrumentation.

        (ix) Data Processing, Collation, Storage & Retrieval.

    (b) Utilisation Sub-sector.

        (i) Hydraulics, Hydraulic structures.

        (ii) Engineering Geology, Geo-hydrology. Geo-Physics, Geochemistry, Seismology.

        (iii) Agriculture, Soil Water Plant-Research, Irrigation, Water Management & Drainage.

        (iv) Material, Soil, Concrete Rock.

        (v) Water-pollution, control and monitoring Wate Conservation, Re-use Research.

        (vi) Sedimentation, Watershed Management.

        (vii) Hydro-Mechanical Equipment.

5. B. Ground Water

    I. Sub-Committee on Ground Water.

    II. Sub-Groups.

        (i) Hydrogeology

        (ii) Groundwater Geophysics.

    (iii) Groundwater Hydrology.
    (iv) Groundwater Engineering.

6. Earth Sciences.
    (i) Astronomy & Astrophysics.
    (ii) Palaeogeophysics & Geodynamics.
    (iii) Seismology.
    (iv) Geothermal Resources.
    (v) Geomagnetism & Geoelectricity.

3. FUEL AND POWER.

1. R&D relating to Electrical Industry Systems
2. M.H.D.
3. Efficiency of Fuel Utilisation:
    (i) Power Sector.
    (ii) Industrial Sector.
4. Institute for Energy Studies.
5. Solar Energy.
6. Tidal Power.
7. Wind Power.
8. Geothermal Energy.
9. Chemical Energy.
10. Aero Gas Turbines for Power Generation.
11. Coal Utilisation.
12. Better Utilisation of Existing Thermal Stations.
13. Coal Slurry Pipeline.
14. HV DC Transmission.

4. HEAVY ENGINEERING.

1. Heavy Electric Equipment for Power House, Transmission Sub-Station, Mill Drives, Traction Equipment, Steam & Water turbines.
2. Heavy Pressure Vessels, Boilers, Heat Exchangers, Dryers etc.
3. Equipment for Fertilizer Plants, Petroleum Refineries and Petro-Chemical Plants, Heavy Duty Pumps, Compressors & Special Pumps for Chemical Industries.
4. Heavy Machine Tools.
5. Steel Plant & Metallurgical Plant Equipment.
6. Mining Machinery, Ore Beneficiation Equipment and Heavy Earth Moving Equipment.
7. Port & Harbour Machinery.
8. Special Requirements of Defence.
9. Cement, Paper & Sugar Machinery.
10. Process Control Instrumentation.
11. Special Machinery for Printing, Packaging, Bottling etc.
12. Equipment for the Manufacture of Fabrics, Felts, Filters etc.
13. Equipment for Wires & Cables, Wire Ropes and Plastic Extrusion.
14. Information Census Survey in Heavy Engineering.

	15. Export Promotion Forecasting Potential.
	16. Drilling Rigs.
	17. Cement Machinery.
5. CHEMICAL INDUSTRIES.	1. Bulk Organic Chemicals/Petrochemicals, Polymers.
	2. Fertilizers & other Nutrients.
	3. Inorganic Chemicals/Electro-Chemicals.
	4. Organic Fine chemicals including Drugs and Pharmaceuticals.
	5. Dyes and Intermediates for Dyes and Pharmaceuticals.
	6. Oils, Fats. Soaps, Surfactants, Paints and Varnishes.
	7. Pesticides.
	8. Marine Chemicals.
	9. Chemical Engineering Research and Design Capability Development.
6. MACHINE TOOLS.	1. Foundry Machinery.
	2. Forming Machinery.
	3. Material Removal Machinery.
	5. Heat Treatment Equipment.
	6. Measuring and Testing Equipment.
	7. Plastics Machinery.
	8. Modernisation of Machinery.
	9. Productivity of Machine Tools.
	10. Defence Production Machines.
	11. Export Potential and Strategy.
	12. Information and Documentation in Machine Tools.
	13. Metal Working and Metal Forming Tools, Including Hand Tools.
7. MINING, STEEL AND METALLURGICAL INDUSTRIES.	1. Ores and Minerals.
	2. Coal and Coke.
	3. Iron and Steel.
	4. Special Steels.
	5. Common Non-ferrous Metals.
	6. Special Non-ferrous Metals.
	7. Rare Metals.
	8. High Purity Metals and Super Alloys.
	9. Foundry & Forge.
	10. Powder Metallurgy.
	11. Refractories.
	12. Ferro Alloys.
	13. Metallic Corrosion and its Prevention.
	14. Mining.
	15. Metallurgical Research in Educational Institutions.

8. AGRICULTURAL EQUIPMENT
9. TRANSPORTATION.
    1. Rail Sub-sector
        - (i) Operations.
        - (ii) Equipment,
        - (iii) Materials.
        - (iv) New Areas of R&D
    2. Road & Water Sub-sector
        - (i) Road & Terminal Facilities.
        - (ii) Inland Water Transport.
        - (iii) Ship & Ship Building.
        - (iv) Road Transport & Vehicles.
        - (v) Special Modes of Transportation.
10. AGRICULTURE.
11. METEOROLOGY.
    1. Meteorology.
    2. Tropical Meteorology.
12. DEFENCE, SPACE AND AERONAUTICS.
13. ELECTRONICS AND ATOMIC ENERGY.
14. CONSUMER INDUSTRIES.
    1. Group on Textiles:
        - (i) Agricultural and Genetic Research on Jute.
        - (ii) Jute process/products Technology and Machinery Development.
        - (iii) Cotton Textiles & Blends.
        - (iv) Synthetics Fibres.
        - (v) Wool process/products Technology and Machinery Development.
        - (vi) Futuristic Development in the Field of Textiles.
    2. Group on Food.
        - (i) Milk and Milk Dairy Products and Animal Husbandry including Meat.
        - (ii) Fish Processing.
        - (iii) Cereals & their Processing Storage and Inspection.
        - (iv) Oils, Proteins & other Subsidiary Foods.
        - (v) Vegetables & Fruits.
        - (vi) Tea, Coffee, Spices and Nuts.
    3. Group on Sugar.
        - (i) Sugar and Sugarcane development.
        - (ii) Sugar Technology & Processing.
        - (iii) Sugar Machinery.
        - (iv) Byproduct Industries.
    4. Group on Leather.

5. Group on Salt.
6. Group on Films and Photographic Chemicals & Camera.
    - (i) Films and Photographic Chemicals.
    - (ii) Camera.
7. Group on Tobacco & Tobacco Products.
    - (i) Health Hazard on the use of Tabacco and Tobacco products.
    - (ii) Tobacco Products and Machinery Development.
    - (iii) Bidi, Zarda, Hookah and Tobacco.
    - (iv) Agricultural and Genetic Research on Tobacco.

15. HOUSING AND URBANISATION AND CONSTRUCTION TECHNOLOGY.

1. Housing and Construction Technology.

A. Housing and other building construction:
1. Materials of Construction.
2. Construction Equipment.
3. Structural Design and Construction Techniques.
4. Foundation and Foundation Structures.
5. Building Services (services for specific functions and environmental efficiency of buildings).
6. Urban Housing, and Physical Planning.
7. Rural Housing and Community Development (physical facilities for rural development.
8. Industrial Buildings.
9. Institutional Buildings. (including architecture and physical planning).
10. Building Practices, Productivity and Management.
11. Education, Training and Manpower.
12. Information and Documentation.
13. Extension Services for the Building Industry.

B. Construction Technology.
1. R & D in Structural Engineering.
2. R&D in Soil Mechanics and Foundation Engineering.
3. R & D in Earthquake Resistant Design and Earthquake Engineering.

II. Urbanisation (rural, urban and regional development)
1. Planning Standards and Planning Methodology for Indian Conditions.
2. Strategy, Planning and Implementation, Mechanisms, for physical plans to get balanced regional development.
3. Planning Group on New Towns (including Industrial Townships)
4. Rapidly Growing Towns (other than Metropolitan Cities); Slum Improvement.
5. Community Wastes/R & D in Public Health Engineering.
6. Socio-technical aspects of Urbanisation.

16. EMPLOYMENT OF SCIENTIFIC AND TECHNICAL MANPOWER
17. MARINE RESOURCES :
    1. Fish & Fisheries.
    2. Marine Environment
    3. Sea Water
    4. Survey of Instruments.
    5. Information Management and Data Collection.
    6. Education Research.
    7. Equipment.
    8. Mineral Oil & Gas.
        - (i) Studies for Offshore Oil and Gas.
        - (ii) Studies for Offshore Minerals.
        - (iii) Marine Geophysical Data Acquisition and Processing for Minerals, Oil & Gas.
        - (iv) Marine Scientific Instruments for Data Acquisition of Offshore Minerals, Oil and Gas
        - (v) Marine Technology (Drilling and Production).
    9. Coastal Zones.
18. ENVIRONMENTAL QUALITY AND POLLUTION CONTROL.
19. RESEARCH SUPPORT, EXTENSION AND EDUCATION.
    - Expert Group set up to look into the plan programmes of grants-in-aid to Institutions under the Department of Science & Technology.
20. NEW MATERIALS.
    1. Ceramics.
    2. Mica.
    3. Electronic Materials.
    4. Thick/Thin Films.
    5. Photo Materials.
    6. Ferrites and other magnetic material.
    7. Composite materials.
    8. Carbon Products.
    9. Liquid crystals.
    10. Centres for Materials Research.
21. GROUP ON AGREEMENTS ON COLLABORATION.
22. INSTRUMENTS.
23. UTILISATION AND RECYCLING OF WASTES.
    1. Agricultural and Animal Wastes.
    2. Mining and Metallurgical Wastes.
    3. Community Wastes.
    4. Wastes from Chemical Industries.
    5. Building Materials from Wastes.
24. KHADI AND VILLAGE INDUSTRIES.
    1. Khadi.
    2. Village Industries.
25. SMALL SCALE INDUSTRIES.
26. REFRIGERATION AND AIR CONDITIONING.
27. INFORMATION.

Total of Panels :	27
Total of Planning Groups.	233
Total number of members :	1855

APPENDIX II

Form for preparation of S & T project proposals for the Science & Technology Plan, 1974-1975 to 1978-79

*1. Area

*2. Group.

*3. Interface.

4. Type.

I. TITLE OF THE PROJECT PROPOSAL

II. DEFINITION OF THE PROBLEM.

III. OBJECTIVES

IV. IMPORTANCE OF THE PROJECT

V. STATUS OF THE TECHNOLOGY.

VI. PRELIMINARY FEASIBILITY AND TECHNO-ECONOMIC MERITS.

VII. IMPLEMENTING ORGANIZATION/LABORATORY.

VIII. PLAN OF WORK

(A) List of activities with time targets etc.

(B) Constitution of Research Groups/Teams.

(C) Research Programming.

(D) Execution of R & D Work.

(E) Commercial Exploitation of Results of R and D.

IX. DURATION.

X. USERS OF THE TECHNOLOGY.

XI. REQUIREMENT OF SCIENTIFIC AND SUPPORTING PERSONNEL.
Please give information in Table 1 attached.

XII. DESCRIPTION OF DUTIES AND SCALES OF PAY FOR EACH PERSON TO BE EMPLOYED ON THE PROJECT.

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*To be filled by the NCST Secretariat.

XIII. **BUDGET**:—Please give information in Table II attached.

XIV **PLANT AND EQUIPMENT** : Please give details for each item of major equipment as under :—

Sl. No.	Name of the Plant/equipment	Total number required under each item of equipment	Country of manufacture	Estimated cost in Rs.

XV. SUMMARY OF SOCIO-ECONOMIC IMPACT

Duration (in yrs.)	R and D inputs (in Rs. lakhs.)	Value of production (in Rs. lakhs)	Import substitution (in Rs. lakhs)	Employment potential	
				During R & D	During comml. Implementation
1	2	3	4	5	6

XVI. DECISION OF THE PLANNING GROUP WITH REASONS

(Approved/Rejected—with reasons)

TABLE 1

Total Manpower Requirements

Category of manpower	Optimum number required to achieve viable functioning.	No. of persons already in employment at commencement of the 5th Plan, if any.	Additional persons to be recruited					Total additional man years required
			1974-75	1975-76	1976-77	1977-78	1978-79	
1	2	3	4	5	6	7	8	9
A. Scientific & Technical Manpower								
1. Post-graduates in science								
2. Post-graduates in agriculture								
3. Degree holders in engineering/technology								
4. Degree holders in medicine								
5. Graduates in science								
6. Graduates in agriculture								
7. Diploma holders in engineering/technology								
8. Technicians trained at I.T.Is.								
9. Others (Skilled Workers, etc.)								
Total 'A'								
B. Other Supporting Manpower								

TABLE II

Financial Outlays

(Rs. in thousands)

Item of Expenditure	1974-75			1975-76			1976-77			1977-78			1978-79			Total		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan-	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
(i) Capital																		
(a) Land & Buildings																		
(b) Plant & Equipment																		
(c) Others, if any (Pl. specify)																		
(d) Total Capital																		
(e) Foreign Exchange component.																		
(ii) Revenue																		
(a) Salaries & Wages																		
(i) S & T Personnel																		
(ii) Others																		
(iii) Total																		
(b) Consumable materials																		
(c) Others e.g. expenses on travelling, maintenance and repairs, stationery, etc.																		
(d) Total Revenue																		
(e) Foreign exchange component, if any.																		
Grand Total (i)+(ii)																		

Note:—If it is not possible to indicate non-plan requirement separately, please state only total estimated outlays.

Guidelines for completing the Form for project proposals for the Science and Technology Plan, 1974-75 to 1978-79

Item I-3: These will be completed by the NCST Secretariat as under :

1. Area State the broad area e.g. health, family planning, natural resources, chemical industry, and so on.

2. Group Specify the Planning Group which will be directly concerned.

3. Interface State the area interface and the Planning Group interface.

Item 4: Type: Please categorise as under:

ST—Short Term projects which will be completed by the end of the Fifth Plan i.e. by 31-3-1979. These may include repetitive, adaptive, ad hoc and by and large clearly defined developmental projects.

MT.—Medium Term projects which will be completed by the end of Sixth Plan period i.e. 31-3-1984

LT—Long Term Projects which will continue beyond 1-4-1984. These would be projects with definite socio-economic objectives.

II. DEFINITION OF THE PROBLEM

Please elaborate the scope and content of the work.

IV. IMPORTANCE OF THE PROJECT

Please list specifically the identified needs and their nature viz. socio-economic, defence, or others. Illustrate in detail the expected benefits with facts, figures and other relevant data as to their scope and content, as for example :

(1) import substitution;

(2) export promotion;

(3) improvement of (a) general economy; (b) present state of knowledge/industry; (c) diversification of production; (d) benefits to society in fields such as health, environment, better and fuller employment and (e) living standards; etc.

(4) possibilities and potentialities for the export of know-how/process technologies;

(5) substitution of foreign collaboration;

(6) development of scientific and technological capability in srategic areas, etc.

(7) cost reduction.

Also describe the importance in terms of knowledge or to find a solution of a practical problem including relation of the proposed research to previous studies in the field or other current studies in progress.

V. STATUS OF THE TECHNOLOGY

Please illustrate the developments that have taken place so far in the field of work proposed both in the country and in other countries of the world. This should be in two separate parts (viz. Indian and International situation) and based on as thorough a literature survey as possible. Special attention should be paid to the patents position.

VI. PRELIMINARY FEASIBILITY AND TECHNO-ECONOMIC MERITS

This is an important section dealing with techno-economic options as decisions. Complete data to assess the relative merits of foreign versus development of indigenous know-how should be given. The data should be more pertinent to parameters such as time targets and the desired scale of indigenous development, extent of drain or savings in foreign exchange, relative costs of indigenous research and import of know-how, the need/desirability of developing indigenous capability.

Points to be covered and data to be furnished under this section include:

(a) Feasibility of exploitation in terms of resource availability.

(b) Viability of the processes for large scale adoption with minimum modifications in plant, apparatus and technology;

(c) Conducting sample market research in consultation with the industry or the association representing the industry to assess demand potential, production/capacity utilization, possible substitutes (their production/Demand/imports) etc.

The feasibility should also cover scientific, technical, operational and entrepreneurial aspects. Data on all these and other aspects should be furnished here.

VII. IMPLEMENTING ORGANIZATION/LABORATORY

Give briefly the reasons for entrusting the work to the chosen organisation/laboratory. The type of facilities available may also be stated.

VIII. PLAN OF WORK

(A) State clearly how the project would be conducted. A detailed and well-prepared plan of work listing activities with time targets is essential for appraisal of a R & D proposal. Also justify why a particular plan of work is chosen in preference to alternative routes available. The justification should cover the important aspects viz. scientific, technical and economic including points such as,

- (i) advancement of fundamental knowledge in which there is a lacuna;
- (ii) collection of knowledge within a definite period of time for Industrial application; and
- (iii) developmental work including process development; etc.

(B) Constitution of Research Groups/Teams

Please identify research teams—laboratory, institutional, inter-institutional, inter agency, project engineers, end-users etc.

(C) Research Programming

State the scope of the research task with time targets including the scale of work, viz. developmental/pilot plant/semi-commercial/proto-type production units. The scale of work should also specify the size/quantity. Provide details of the constitution of pilot plant developmental task force. State the extent of collaboration required/proposed with design/project engineering groups/firms users of technology.

(D) Execution of R and D work

Adoption of PERT for laboratory/pilot plant/proto-type developmental work.

(E) Commercial Exploitation of Results of R & D

- (a) Evaluation;
- (b) Project engineering;
- (c) Transfer of technology to users;
- (d) After-Sales-Service including further developments/improvements of technology.

IX. DURATION

Give the duration of proposed work. The duration should not exceed 5 years for short-term priority S & T Plans. This period will normally include all activities in the 'total system' for applied/developmental/industrial projects.

X. REQUIREMENT OF SCIENTIFIC AND SUPPORTING PERSONNEL

Estimate the total man years of professional, technical and supporting assistance required to accomplish the research task. For example, if the Chief investigator plans to spend one quarter of his time on the project and he had two full-time technical assistants and one half-time technical assistant, the total would be 13.75 man years for a project targeted for five years. Please give the information in Table-1.

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